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April 1990

Final Report - Revision

Attachment to Phase II Comprehensive Site Investigation: Hranica Site Endangerment Assessment Buffalo Township, Pennsylvania

Prepared For:

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Environmental Sciences Center
Coatings and Resins

April 10, 1990

Mr. Garth Connor
SARA Special Site Section
US EPA Region III
841 Chestnut Street
Philadelphia, PA 19107

Re: Hranica Site - Revised Remedial Investigation Report

Dear Mr. Connor:

Attached please find four (4) copies of the Endangerment Assessment for the Hranica site located in Buffalo Township, Pennsylvania, revised in accordance with comments received from US EPA on March 12, 1990. The revised Phase II Comprehensive Site Investigation report is being transmitted under separate cover from Dunn Geoscience Corporation. This submittal of a revised report is being made pursuant to Section VIII (B) (10) of the Administrative Consent Order (US EPA Docket No. III-87-1-DC) between PPG Industries, Inc. and US EPA dated February 17, 1987, and the project schedule.

Please call Bob Halden at (412) 963-5862 or me at (412) 963-5823 if you have any comments or require additional information.

Sincerely,

Marian Broz
/m

cc: G. E. Palchak/R. Halden/file HR-603.1
Anita Stainbrook - PADER
G. Ahnell - Dunn Geoscience
M. Dubinsky - IT Corporation
P. M. King

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Attachment to Phase II Comprehensive Site Investigation: Hranica Site Endangerment Assessment Buffalo Township, Pennsylvania

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EXECUTIVE SUMMARY

In December 1989, PPG Industries, Inc. (PPG), requested IT Corporation (IT) to prepare an Endangerment Assessment (EA) for the Hranica site located in the southeastern part of Butler County in Western Pennsylvania. An EA is required for sites listed on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. An EA was prepared previously by Dunn Geoscience Corporation (Dunn) and reviewed by the U.S. Environmental Protection Agency (U.S. EPA). Comments on the EA received on November 27, 1989 and March 12, 1990 from U.S. EPA are addressed by IT as part of this scope of work.

The site setting, data, evaluation, and hydrogeology presented in "Phase II Comprehensive Site Investigation and Endangerment Assessment" (Dunn, 1989) formed the basis for this EA.

The objective of the EA is to define possible health risks and potential ecological impacts associated with exposure to the constituents still present in the various environmental site media, primarily groundwater and surface soils. The EA is used as input into the Feasibility Study (FS) to provide a focus on the most appropriate remedies which reduce identified risks (if any) to acceptable levels.

The principal pathways of concern addressed in the EA include an on-site direct soil contact, ingestion and inhalation scenario, and an off-site residential inhalation, groundwater ingestion and showering scenario. An ecological

assessment is presented to characterize potential risks to nonhuman receptors.

Air emissions for the on- and off-site inhalation scenarios are based on estimations of wind and vehicle erosion rates for particulates, and on methane-induced emissions of soil gas. A box model is used to calculate air concentrations for the on-site trespass scenario, while a Gaussian dispersion model is employed for estimating the chemical concentrations downwind of the site at the nearest residence (approximately 2,000 feet from the property boundary). A showering model is used to estimate the dose of volatilized organics inhaled during off-site showering with groundwater.

The Hranica site is partitioned into two separate zones for purposes of the soil exposure pathway analysis: the ash pile area and the non-ash pile area. The partitioning of the site into two separate zones was performed because chemical constituent levels and remedial strategies are expected to be different between the two areas.

The potential receptors chosen for the public health risk characterization include an adult and child either (1) trespassing on the site an average of once per week or (2) being exposed continuously while living off site.

To evaluate the significance of the calculated site-associated risk, the estimates are compared to target risk levels. U.S. EPA's guidelines state that the total incremental carcinogenic risk for an individual resulting from exposure at a hazardous waste site should be between 10^{-7} and 10^{-4}. For purposes of this EA, Superfund's bench mark carcinogenic risk of 10^{-6} will be used to provide

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guidance in assessing the significance of the reported incremental cancer risk.

Based on U.S. EPA guidelines, the target level for noncarcinogens is a hazard index of 1.0. When more than one population is potentially exposed, as is the case for the Hranica site, the population determined to be at greatest risk is used for comparison to these target levels.

Groundwater

Summary risk estimates for groundwater indicate acceptable risks to human health. Incremental carcinogenic risks to adult and child potential receptors are both less than 1 x 10^{-6}. Similarly, hazard indices to these potential receptors are less than 1.0.

Ash Pile Soils

Summary risk estimates for ash pile area soils suggest potential health risks under the trespass scenario to both adults and children visiting the site an average of once per week. Incremental carcinogenic risks and hazard indices exceed the recommended standards protective of human health. The exposure pathway contributing most to potential risk is the incidental ingestion of surficial soil, primarily due to the elevated levels of polychlorinated biphenyls (PCBs) and lead.

Non-Ash Pile Soils

Summary risk estimates for non-ash pile area soils show acceptable risks for both on-site and off-site exposure from noncarcinogens, and acceptable incremental carcinogenic risks to off-site residents. The incremental cancer risk to an adult trespassing on the Hranica site is 1.5 x 10^{-6},

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while the incremental risk to a child is 1.1×10^{-6}. Although these incremental risks slightly exceed the bench mark standard of 1×10^{-6}, they are not considered significant given the safety factors and overconservative assumptions incorporated into the overall exposure assessment and risk characterization.

Soil Gas

Summary risk estimates for soil gas indicate acceptable risks for all subpopulations.

Composite Risks to Receptors

Because of the likelihood of the subpopulations being exposed to more than one medium, risks from each of the media were combined. These composite risks are segregated into two scenarios; a risk characterization including the ash pile area and a risk characterization including the non-ash pile area. These two scenarios are presented to facilitate the selection of appropriate remedial alternatives in the FS currently being prepared.

The composite carcinogenic risk is greatest for an adult trespasser visiting the site under the scenario including the ash pile area soils. This carcinogenic risk (9.8×10^{-6}) exceeds the bench mark of 1×10^{-6}. As discussed previously, the ash pile area soils themselves are primarily responsible for this finding and not exposure from soil gas.

Under the scenario including only the non-ash pile area soils, the greatest composite cancer risk is 1.5×10^{-6}. This value is not significantly above the standard given the safety factors and overconservative assumptions built into the risk characterization. The composite hazard index is

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below 1.0, indicating an acceptable public health risk to noncarcinogens.

Ecological Risk Characterization

Chemical constituents found in surface water samples collected from seeps and streams near the site exceeded aluminum, copper, and zinc water quality criteria for the protection of aquatic life. However, due to the ephemeral nature of the streams and their limited potential to support a diverse aquatic community, it is our opinion that potential adverse effects are expected to be insignificant.

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1.0 INTRODUCTION

This report is an EA for the Hranica site. An introduction to the report is presented in Chapter 1.0. The Selection of Constituents of Concern is presented in Chapter 2.0. Chapter 3.0 presents the Exposure Assessment. Chapter 4.0 presents the Public Health Risk Characterization; and Chapter 5.0, the Ecological Risk Characterization.

1.1 BASIS FOR THE RISK ASSESSMENT

In December 1989, PPG requested IT to prepare an EA for the Hranica site located in the southeastern part of Butler County in Western Pennsylvania. An EA is required for sites listed on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. An EA was previously prepared by Dunn and reviewed by the U.S. EPA. Comments on the EA received on November 27, 1989 from the U.S. EPA are addressed by IT as part of this scope of work.

The site setting, data, evaluation, and hydrogeology presented in the "Phase II Comprehensive Site Investigation and Endangerment Assessment" (Dunn, 1989) formed the basis for this EA.

1.2 SITE HISTORY AND SETTING

The Hranica site history and setting have been previously described in detail by IT (1987) and by Dunn (1989). A summary of this information is presented below for the EA.

The Hranica site is a 15-acre area located near Sarver, in Butler County, Pennsylvania, approximately 21 miles northeast of Pittsburgh. It is surrounded by corn fields, orchards and wooded areas. The site was used for municipal waste disposal and for the disposal of PPG and Aluminum Company of America (ALCOA)

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wastes from 1966 to 1974. In 1974 all activities at the site ceased.

Industrial wastes stored, incinerated or dumped on site included paints and solvents, plating wastes, metal sludges and waste oils. In 1983 to 1984, over 19,000 drums of waste products were removed along with approximately 4,000 cubic yards of excavated soil. According to the Dunn report, following these waste remediation tasks, grading and soil capping were completed to reduce surface ponding and infiltration. These activities reduced the likelihood of further environmental degradation and off-site migration of mobile chemicals. Regraded sections of the site now support vegetative cover.

1.3 OBJECTIVES OF THE ENDANGERMENT ASSESSMENT

The objective of the EA is to define possible health risks and potential ecological impacts associated with exposure to the constituents still present in the various environmental site media, namely groundwater and surface soils. The EA is used as an input to the FS to provide a focus on the most appropriate remedies which reduce identified risks, if any, to acceptable levels.

Health protective assumptions are used in each phase of the EA. Each stage builds on previous assumptions, such that the overall estimated risks associated with exposure to constituents of potential concern tend to be overestimated.

1.4 APPROACH

The principal pathways of concern addressed in the EA include an on-site direct soil contact, ingestion and inhalation scenario and an off-site residential inhalation, groundwater ingestion, and showering scenario. An ecological assessment is presented in Section 5.0 to characterize potential risks to nonhuman receptors.

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Air emissions for the on- and off-site inhalation scenarios are based on estimations of wind and vehicle erosion rates for particulates, and induced emissions of soil gas by methane transport. Methane is a common landfill gas. A box model is used to calculate air concentrations for the on-site trespass scenario, while a Gaussian dispersion model is employed for estimating the chemical concentrations downwind of the site at the nearest residence (approximately 2,000 feet from the property boundary). A showering model is used to estimate the dose of volatilized organics inhaled during off-site showering with groundwater.

The potential receptors chosen for the public health risk characterization include an adult and child either (1) trespassing on the site an average of once per week or (2) being exposed continuously while living off site.

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2.0 SELECTION OF CONSTITUENTS OF CONCERN

The selection of constituents of concern is a screening process performed to reduce to a manageable number the constituents assessed in a baseline EA. In determining the constituents of concern, guidance provided in the Human Health Evaluation Manual (U.S. EPA, 1989a) was used. As recommended, the selection was based on inherent toxicity, measured concentrations in various media at the site, distribution and frequency of detection, and potential for human exposure. Under current site conditions, groundwater, surface soil, soil gas, surface water, and sediment are the media at the Hranica site to which human populations may be potentially exposed.

2.1 GROUNDWATER

Concentrations of chemical constituents found above detection limits in the deep groundwater aquifer are presented in Table 1. Data shown represent samples collected from deep groundwater monitoring wells screened in the Buffalo sandstone lithologic unit over two rounds of groundwater sampling in the fall of 1988 and the spring of 1989 (Dunn, 1989).

The shallow aquifer (Morgantown sandstone) appears to be a perched system of limited extent. Many monitoring wells screened in this lithologic unit have been dry since project work began in 1988 (Dunn, 1989). The aquifer discharges to the surface through seeps and springs along the hillsides, and along the geologic contact between the Morgantown and Birmingham Formations. As a result of the shallow aquifer's limited recharge, extent and water storage capacity, as well as its low hydraulic conductivity of 1.6 foot per day (ft/day) (5.6×10^{-4} centimeters per second [cm/sec]), this aquifer is unsuitable for residential water supply.

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The intermediate aquifer (Birmingham Shale and Pittsburgh Red Beds) acts more as an aquitard than an aquifer. An aquitard is a saturated but poorly permeable structure that impedes groundwater movement and does not yield water freely to wells. An aquitard may transmit water to or from adjacent aquifers, and, where sufficiently thick, may constitute a groundwater storage zone. The intermediate aquifer functions as a semipermeable confining layer between the upper and lower aquifers. Horizontal flow of groundwater in the intermediate aquifer is insignificant as the hydraulic conductivity averages 0.86 ft/day (3.0×10^{-4} cm/sec) (Dunn, 1989). Thus, this aquifer is unsuitable for residential water supply.

Results from the shallow and intermediate groundwater systems are not included in the EA because (1) neither serves as a water supply for nearby private drinking water wells (Dunn, 1990) and (2) future use of either aquifer as a residential water supply is highly unlikely given the expected low water yields. In addition, the shallow aquifer is of limited areal extent and does not appear to extend significantly beyond the boundaries of the Hranica site.

As the deep groundwater system within the Buffalo sandstone lithologic unit supplies water to the domestic wells proximate to the site, this aquifer was selected to represent the most likely potential source of exposure. However, most residences proximate to the site are served by municipal water supplies (Dunn, 1990) and groundwater exposure is expected to be minimal.

Although domestic well samples have previously been collected (Dunn, 1989), the water samples were filtered by an in-line filtration system prior to metals analysis. Filtration of these samples irreparably compromised the inorganic results and they are considered invalid and not appropriate for use in risk calculations. Alternatively, on-site groundwater constituent

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concentrations were modeled from the site to the nearest human receptor (Section 3.1).

Constituents of concern were selected based on concentration, frequency of occurrence, and comparison with drinking water standards or health advisories (Table 1). Constituents were generally not selected if the frequency of occurrence was less than two. The following constituents of concern were identified:

- Benzene
- 4-Methyl-2-Pentanone (MIBK)
- 2-Butanone (MEK)
- Acetone
- Naphthalene
- Cadmium
- Chromium
- Lead
- Beryllium
- Nickel

Benzene is carcinogenic via oral exposure. Through the inhalation route of exposure cadmium and beryllium are classified as Probable Human Carcinogens, while benzene and hexavalent chromium are categorized as Human Carcinogens. Lead is considered a Probable Human Carcinogen, although cancer potency factors (CPFs) are not as yet available.

Several constituents were not selected as constituents of concern because they were detected in laboratory blanks (e.g., bis(2-ethyl-hexyl)phthalate) or are commonly used laboratory compounds (e.g., methylene chloride).

2.2 SOIL

Concentrations of chemical constituents found in soil above detection limits are shown in Table 2. Data presented include samples from surface and near-surface soil borings; i.e., less than three feet (Dunn, 1989). Only surficial soils are presented

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because exposure from subsurface material; i.e., greater than three feet, is not expected at the site. Normally occurring soil elements such as calcium, iron, magnesium, potassium, and sodium are not presented due to their limited toxicity.

Constituents of concern were chosen based on concentrations relative to normally occurring background levels, frequency of occurrence, and the presence/absence of human health chronic daily intake (CDI) standards (reference doses [RfDs] and/or CPFs) for individual constituents.

A constituent was selected as a contaminant of concern if a human health standard was available, the frequency of occurrence was greater than 1 out of 14 samples, and the maximum concentration detected at the site was greater than the minimum level generally found in uncontaminated background soils. Tetrachloroethylene was selected although it was only found once, because it is a Probable Human Carcinogen through both ingestion and inhalation pathways, and the concentration detected was considerably above the quantification limit.

The following soil constituents of concern were selected for use in the EA:

- Toluene
- Xylenes (total)
- Tetrachloroethylene
- Trichloroethylene
- 1,1,1-Trichloroethane
- Naphthalene
- Bis(2-ethylhexyl)phthalate
- Polychlorinated biphenyls (PCBs)
- Antimony
- Arsenic
- Barium
- Cadmium
- Chromium
- Lead
- Manganese
- Mercury
- Nickel

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- Selenium
- Zinc
- Cyanide

Carcinogenic constituents include tetrachloroethylene, trichloroethylene, bis(2-ethylhexyl)phthalate, PCBs, arsenic, cadmium, chromium, and nickel via oral and/or inhalation exposure. Lead is considered a Probable Human Carcinogen, although CPFs are not as yet available.

2.3 SOIL GAS

Concentrations of volatile organic compounds detected in soil gas are presented in Table 3. Values presented represent soil-gas survey results (Dunn, 1989). Constituents of concern were selected based upon the availability of an inhalation reference dose or cancer potency factor from the literature (U.S. EPA Health Effects Assessment Summary Tables, 1989). Constituents of concern selected include:

- Benzene
- Toluene
- Xylenes, total

Of these constituents, benzene is a Human Carcinogen.

2.4 SURFACE WATER AND SEDIMENTS

Unnamed tributaries of McDowell Run and Little Bull Creek drain the site. Flows are intermittent (generally less than a few gallons per minute) and mostly unmeasurable on the property with standard field instruments (Ahnell, 1989). Neither unnamed tributary is a known source of drinking water, and exposure via dermal contact with water (e.g., wading) is unlikely given the unattractive nature of the site for water play activities. Exposure to human populations is not expected; therefore, no risks are anticipated. Accordingly, no human health constituents of concern were chosen for surface water.

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Similarly, as the unnamed tributaries are not large enough to support or encourage wading or swimming activities, no risks are anticipated from direct contact with, or incidental ingestion of, sediments. Accordingly, no sediment constituents of concern were selected.

Although it is likely that some of the intermittent flow is derived from the upper aquifer, which has been shown to be slightly contaminated with site constituents (Dunn, 1989), exposure to these constituents is considered insignificant for the reasons presented previously.

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3.0 EXPOSURE ASSESSMENT

The purpose of this section is to describe the exposure pathways related to chemical transport and the potential exposure of human receptors at the Hranica site. The primary purpose of an exposure assessment is to determine the concentration levels over time and space in each environmental medium where humans may come in contact with the constituents of concern. The primary components of an exposure assessment include a pathway analysis, an identification of appropriate exposure scenarios, and an estimation of exposure.

The potential exposure pathways subsequently described are as follow:

- Groundwater pathway
  - Water ingestion
  - Inhalation of volatilized constituents
  - Dermal contact
- Soil pathway
  - Soil ingestion
  - Soil dust inhalation
  - Dermal contact
- Soil gas pathway
  - Inhalation

Two age groups represent the potentially exposed off-site population, children ages 0 through 18 having an average body weight of 34 kilograms (kg) and an adult weighing 70 kg (U.S. EPA, 1989b). Similar assumptions were used for the potentially exposed on-site populations, except the child exposure duration was reduced from 18 years to 6 years to more accurately reflect potential trespass activity. Exposure estimates were based on the reasonable maximum exposure for each age group and depend on environmental media concentrations at the point of exposure. Reasonable maximum exposure was defined for purposes of this EA as the 95 percent upper bound of the arithmetic mean for a

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particular set of data, as recommended by U.S. EPA (1989a). Media concentrations used in estimating concentrations at the point of exposure are presented in Appendix A (from Dunn, 1989). In calculating the 95 percent upper bound, one-half the quantification limit was used to estimate the concentration of constituents below the detection limit.

The exposure routes for each pathway were evaluated, and intakes expressed in milligrams per day (mg/day), were derived for the population subgroups. By dividing the intake expression by the appropriate body weight, a dose expressed in mg/kg/day was determined for each age group.

3.1 GROUNDWATER PATHWAY

Groundwater exposure was considered for the nearest off-site receptor source, a private drinking well located approximately 2,000 feet from the site boundary along the groundwater flow path (Dunn, 1989; DW-5/George Pajer well). The Vertical Horizontal Spread (VHS) model (as proposed in the Federal Register, November 27, 1985) was used to estimate concentrations of constituents of concern at the point of exposure (Appendix B).

The VHS model is recommended for use by the U.S. EPA and is used to estimate downgradient contaminant concentrations due to hydrodynamic dispersion and diffusion.

There is no current on-site production well nor is this former disposal site likely to be used for residential purposes. Therefore, ingestion of groundwater from an on-site source was not considered to be a viable exposure pathway.

3.1.1 Water Ingestion

The following assumptions were used to estimate an exposure from off-site groundwater ingestion proximate to the Hranica site:

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- The receptors are a child ingesting 1.0 liter/day (l/day) and an adult ingesting 2.0 l/day every day for 18 and 30 years, respectively (U.S. EPA, 1989b).

- The groundwater contains the concentration of constituents as estimated from the VHS model (Appendix B).

- For carcinogens, the averaging time used in all the exposure pathway calculations is 70 years. For noncarcinogens, the averaging time is equal to the duration of exposure (i.e., 18 and 30 years for child and adult, respectively).

3.1.2 Water Inhalation

A model has been used to quantitatively evaluate the potential human health risk due to exposure from organic constituents in groundwater that may volatilize while showering. A showering model developed by Foster and Chrostowski (1986) is used to estimate concentrations of volatile organic constituents of concern at the point of exposure (Appendix C).

The following assumptions were used in the CDI scenario:

- The receptors are a child and an adult having breathing rates of 0.8 and 0.6 cubic meters (m^3)/hour, respectively (U.S. EPA, 1989b).

- The receptor is exposed once a day for 12 minutes in the shower and for 15 minutes in the shower room (U.S. EPA, 1989a).

- The dose received is estimated from the showering model (Appendix C).

- Retention of organics in the lung after inhalation and the absorption factor for inhalation of organic vapors is 100 percent.

- For carcinogens, the averaging time used in all the exposure pathway calculations is 70 years. For noncarcinogens, the averaging time is equal to the duration of exposure (i.e., 18 and 30 years for child and adult, respectively).

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3.1.3 Dermal Contact

While showering, dermal contact with constituents in the groundwater will occur. The dose expected from this pathway is minimal when compared to direct ingestion, but is nonetheless considered for the total dose to the receptor. The following assumptions have been used:

- The receptors are a child and adult having total skin areas of 9,310 and 19,400 square centimeters (cm^2) respectively (U.S. EPA, 1989b).
- The receptor is exposed once a day for 12 minutes (U.S. EPA, 1989a).
- Dermal permeability constants (PC) are chemical specific. Values of 0.41 and 5.0 cm/hour are used for benzene and MEK, respectively (U.S. EPA, 1988). Note that MEK PC was used as a surrogate for MIBK and default PCs for water (0.0008 cm/ hour) were used for naphthalene and acetone.
- For carcinogens, the averaging time used in all the exposure pathway calculations is 70 years. For noncarcinogens, the averaging time is equal to the duration of exposure (i.e., 18 and 30 years for child and adult, respectively).

3.2 SOIL PATHWAY

Soil exposure (ingestion and dermal contact) was considered for on-site receptors, characterized as trespassers visiting the unrestricted site. While direct soil contact and incidental ingestion pathways were based on actual soil concentrations (Appendix A), the inhalation pathway for soil particles was based on ambient air concentrations modeled from the ground to the atmosphere as a result of wind erosion and vehicular activity (Appendix D). Inhalation of soil particles was considered for both on-site trespass and off-site residential receptors.

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The Hranica site was partitioned into two separate zones for purposes of the soil exposure pathway analysis. The partitioning was based on the actual location of the soil borings (Figure 1) and on the concentrations of constituents known to be representative of ash material. The levels of the indicator constituents barium, cadmium, chromium, lead, mercury, and selenium in the ash pile area were more similar to indicator concentrations in a known ash sample, compared with non-ash pile area soil borings (Table 4). The first zone included the ash pile area (Borings B5, B9, B11, and B17), while the second zone included non-ash pile areas (Borings B2 to B4, B6, B10, B13 to B16, and B18; Figure 1, Appendix A). Borings B1, B7, B8, and B12 were not included because all soil samples collected from these borings are from depths greater than 3.0 feet and were not appropriate for use in the exposure scenarios presented because exposure to soils greater than 3.0 feet is not expected.

3.2.1 Soil Ingestion

The receptors for this scenario include a child and adult inadvertently ingesting soil while trespassing on the site. The following assumptions have been used:

- Soil ingestion rates are 200 and 100 mg/day for child and adult receptors, respectively (LaGoy, 1987).
- 100 percent of the chemical adsorbed on soil particles is absorbed by the gastrointestinal tract, and the fraction ingested from contaminated sources is assumed to be 100 percent.
- The exposure frequency is 52 visits per year for both receptors because this is a remote site surrounded by rugged terrain. This value assumes approximately two visits per week during nonwinter months.
- For carcinogens, the averaging time used in all the exposure pathway calculations is 70 years. For noncarcinogens, the averaging

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time is equal to the duration of exposure (i.e., 6 and 30 years for child and adult, respectively).

3.2.2 Soil Inhalation

Potential exposure by inhalation of mobilized soil particles exists for receptors trespassing on the site and for receptors living off site. Mathematical models were used to estimate potential soil particle concentrations in air from wind erosion and vehicular traffic both at the site and at off-site receptors (Appendix D). The assumptions used to calculate CDI are as follows:

- The receptors are a child and an adult having breathing rates of 0.8 and 0.6 m^3/hour, respectively (U.S. EPA, 1989b).
- The on-site receptor is exposed 52 times per year for 8 hours per visit, while the off-site residential receptor is exposed 365 days per year for 24 hours per day.
- The air contains the concentration of contaminants as estimated from the soil emission model, box model, and downfield dispersion model (Appendix D).
- Absorption of constituents adsorbed to particulates (metals and organics) following inhalation is 100 percent.
- For carcinogens, the averaging time used in all the exposure pathway calculations is 70 years. For noncarcinogens, the averaging time is equal to the duration of exposure (i.e., 6 years for a child trespassing on site, 18 years for a child living off site, and 30 years for an adult.

3.2.3 Dermal Contact

The expected dose to a receptor from dermal absorption is usually minimal when compared to ingestion; however, it is considered in the soil pathway to obtain a total dose to the receptor. A child playing at the Hranica site may be exposed to soils via the

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hands, arms, and legs assuming he or she is wearing shorts and a short-sleeved shirt. An adult passing through the area is expected to only have contact with soil on the arms and hands. The following assumptions were used in this scenario:

- The potential skin surface area available for contact for a child is 3,910 cm^2, which includes the hands, arms and legs. The surface area of 3,120 cm^2 for an adult includes the hands and arms only (U.S. EPA, 1989a).
- Contact occurs approximately 52 times per year.
- Dermal absorption of chemicals is 1.0 percent (Poiger and Schatter, 1980).
- Soil adherence factor is 1.0 $mg/cm^2/day$ (Schaum, 1984). This value represents the median adherence factor for the range of values 0.5 to 1.5 mg/cm^2, from Schaum (1984).
- For carcinogens, the averaging time used in all the exposure pathway calculations is 70 years. For noncarcinogens, the averaging time is equal to the duration of exposure (i.e., 6 and 30 years for child and adult, respectively).

3.3 SOIL GAS PATHWAY

Potential exposure by inhalation of soil gas exists for receptors trespassing on site and for receptors living off site. Mathematical models were used to estimate potential soil-gas concentrations in the breathing zone for both on-site and off-site receptors (Appendix E). CDI assumptions include:

- The receptors are a child and an adult having breathing rates of 0.8 and 0.6 m^3/hour, respectively (U.S. EPA, 1989b).
- The on-site receptor is exposed 52 times per year for 8 hours per visit, while the off-site residential receptor is exposed 365 days per year for 24 hours per day.

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- The air contains the concentration of contaminants as estimated from the soil emission model, box model, and downfield dispersion model (Appendix E).

- For carcinogens, the averaging time used in all the exposure pathway calculations is 70 years. For noncarcinogens, the averaging time is equal to the duration of exposure (i.e., 6 years for a child trespassing on site, 18 years for a child living off site, and 30 years for an adult).

3.4 ESTIMATION OF DAILY DOSE

The quantitative risk assessment was based on procedures outlined in the Human Health Evaluation Manual (U.S. EPA, 1989a), with modifications where appropriate. For references on exposure assumptions, see the previous section.

3.4.1 Water Ingestion

The CDI due to the ingestion of groundwater by off-site receptors is calculated by:

$$CDI = (CW*IR*EF*ED)/(BW*AT)$$

where

CDI = chronic daily intake in mg/kg/day,

CW = concentration of constituent in water in mg/l,

IR = ingestion rate, 1 l/day for a child and 2 l/day for an adult,

EF = exposure frequency, 365 days/year,

ED = exposure duration, 18 years for a child and 30 years for an adult (constant for all off-site exposure pathways),

BW = body weight, 34 kg for a child and 70 kg for an adult (constant for all exposure pathways), and

AT = averaging time, 70 years *365 days for carcinogens and ED*365 days for noncarcinogens (constant for all exposure pathways).

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3.4.2 Soil Ingestion

The dose due to the inadvertent ingestion of surface soils is calculated by the following:

$$CDI = (CS*IR*CF*FI*EF*ED)/(BW*AT)$$

where

CS = concentration of chemical in soil in mg/kg,

IR = ingestion rate, 200 mg/day for children and 100 mg/day for adults,

CF = conversion factor, 10^{-6} kg/mg,

FI = fraction ingested from contaminated area, assumed to be 100 percent (unitless),

EF = exposure frequency, 52 days/year,

ED = exposure duration, 6 years for a child and 30 years for an adult (constant for all on-site exposure pathways).

3.4.3 Inhalation

The CDI for inhalation of volatilized groundwater, soil gas or soil particulates is calculated by:

$$CDI = (CA*IR*ET*EF*ED)/(BW*AT)$$

where

CA = concentration of chemical in air (vapor or particulate) in mg/m^3,

IR = inhalation rate, 0.8 and 0.6 m^3/hour for child and adult, respectively,

ET = exposure time: 0.2 hours/day for showering, 8 hours/day for on-site receptor, and 24 hours/day for off-site receptor, and

EF = exposure frequency: 365 days/year for showering, 52 days/year for on-site receptor, and 365 days/year for off-site receptor.

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3.4.4 Dermal Contact With Water

The CDI for dermal contact with water while showering is calculated by using the following equation:

$$CDI = (CW*SA*PC*ET*EF*ED*CF)/(BW*AT)$$

where

CW = concentration of constituent in water in mg/l,

SA = skin surface area available for contact, 9,310 cm^2 for a child and 19,400 cm^2 for an adult,

PC = chemical-specific dermal permeability constant in cm/hour,

ET = exposure time, 0.2 hour/day,

EF = exposure frequency, 365 days/year, and

CF = conversion factor for water, 1 liter/1,000 cm^3.

3.4.5 Dermal Contact With Soil

The CDI for dermal contact with chemicals in soils is calculated by:

$$CDI = (CS*CF*SA*AF*ABS*EF*ED)/(BW*AT)$$

where

CS = concentration of chemical in soil in mg/kg,

CF = conversion factor, 10^{-6} kg/mg,

SA = skin surface area available for contact, 3,910 cm^2/event for a child's hands, arms and legs, and 3,120 cm^2/event for the arms and hands of an adult,

AF = soil to skin adherence factor, 1.0 mg/cm^2/day,

ABS = absorption factor, 1.0 percent (unitless), and

EF = exposure frequency, 52 events/year.

4.0 PUBLIC HEALTH RISK CHARACTERIZATION

4.1 APPROACH

This section characterizes the risks to public health associated with exposure to groundwater, soil, and soil-gas constituents identified at the Hranica site. Potential risks involve exposure of two subpopulations: adults and subadults. Subadults were characterized as either children living off site with an exposure duration of 18 years or children trespassing on site with an exposure duration of 6 years.

On-site risks are limited to trespasser exposure. This exposure may occur from contact with surficial soils (ingestion, inhalation, and direct contact) and from inhalation of soil gas. Off-site residential risks include exposure to groundwater (ingestion, inhalation, and direct contact), and inhalation of soil gas and soil dust. All soil exposure pathways have been segregated into "ash areas" and "non-ash areas" to characterize the risks from these two areas separately. The partitioning of the site into these two areas was conducted because the concentrations of chemical constituents was expected to be significantly different between the two areas.

The magnitude and types of risks depend on the nature, duration, and frequency of exposure to contaminants, and the characteristics of the exposed populations. This information, presented in Section 3.0 and Appendices A, B, C, D, and E, forms the basis for this risk characterization. Carcinogenic risk estimates were determined by multiplying the CDI level for each carcinogen by its U.S. EPA carcinogenic potency factor (CPF; Appendix F), resulting in a chemical-specific lifetime incremental cancer risk. Cancer risks associated with multiple

constituents were summed for each potentially exposed population to yield a lifetime incremental cancer risk for a hypothetical individual within each subpopulation. Quantitative risk estimates were calculated for each constituent of concern for the populations at risk using computer spreadsheets developed by IT (Appendix G).

Noncarcinogenic risk estimates were determined by dividing CDI levels for each noncarcinogen by the appropriate reference dose (RfD) for the particular constituent (Appendix F). The resulting ratio is termed a risk ratio. The sum of the risk ratios for individual constituents is called the hazard index. If this ratio is less than or equal to 1.0, no adverse health effects are anticipated from the predicted CDI level. If the ratio is greater than 1.0, the predicted CDI level could potentially cause adverse health effects. This determination is imprecise because derivation of the relevant standards or guidelines involves the use of multiple safety factors. In addition, the risk ratios for individual constituents should properly be summed only if their target organs or mechanisms of action are identical. Therefore, the potential for adverse health effects for a mixture having a hazard index in excess of 1.0 must be assessed on a case-by-case basis.

Hazard indices were determined for each potentially exposed population. Tables 5 through 8 present the carcinogenic and noncarcinogenic risks for the Hranica site for exposure to groundwater, soils, and soil gas.

4.2 RISK CHARACTERIZATION

To evaluate the significance of the calculated site-associated risk, the estimates are compared to target risk levels. U.S. EPA's guidelines state that the total incremental carcinogenic

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risk for an individual resulting from exposure at a hazardous waste site should be between 10^{-7} and 10^{-4}. For purposes of this EA, Superfund's bench mark carcinogenic risk of 10^{-6} will be used to provide guidance in assessing the significance of the reported incremental cancer risk.

Based on U.S. EPA guidelines, the target level for noncarcinogens is a hazard index of 1.0. When more than one population is potentially exposed, as is the case for the Hranica site, the population determined to be at greatest risk is used for comparison to these target levels.

4.2.1 Groundwater

Summary risk estimates for groundwater indicate acceptable health risks to human health (Table 5). Incremental carcinogenic risks to adult and child potential receptors are both less than 1×10^{-6}. Similarly, hazard indices to these potential receptors are less than 1.0.

4.2.2 Ash Pile Soils

Summary risk estimates for ash pile area soils suggest potential health risks under the trespass scenario to both adults and children visiting the site an average of once per week (Table 6). Incremental carcinogenic risks and hazard indices exceed the recommended standards protective of human health. The exposure pathway contributing most to potential risk is the incidental ingestion of surficial soil, primarily due to the elevated levels of PCBs and lead.

4.2.3 Non-Ash Pile Soils

Summary risk estimates for non-ash pile area soils (Table 7) show acceptable risks for both on-site and off-site exposure from noncarcinogens, and acceptable incremental carcinogenic risks to

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off-site residents. The incremental cancer risk to an adult trespassing on the Hranica site is 1.5×10^{-6} and the cancer risk to a child trespassing on site is 1.1×10^{-6}. Although these incremental risks slightly exceed the bench mark standard of 1×10^{-6}, they are not considered significant, given the safety factors and overconservative assumptions incorporated into the overall exposure assessment and risk characterization.

4.2.4 Soil Gas

Summary risk estimates for soil gas (Table 8) indicate acceptable risks for all subpopulations.

4.2.5 Composite Risks to Receptors

Because of the likelihood of the subpopulations being exposed to more than one medium, risks from each of the media were combined (Table 9). These composite risks are segregated into two scenarios; a risk characterization including the ash pile area and a risk characterization including the non-ash pile area. These two scenarios are presented to facilitate the selection of appropriate remedial alternatives in the FS currently being prepared.

As illustrated in Table 9, the composite carcinogenic risk is greatest for an adult trespasser visiting the site under the scenario including the ash pile area soils. This carcinogenic risk (9.8×10^{-6}) exceeds the bench mark of 1×10^{-6}. As discussed previously, the ash pile area soils themselves are primarily responsible for this finding and not exposure from soil gas.

Under the scenario including only the non-ash pile area soils, the greatest composite cancer risk is 1.5×10^{-6}. This value is not significantly above the standard, given the safety factors

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and overconservative assumptions built into the risk characterization. The composite hazard indices are below 1.0, indicating an acceptable public health risk to noncarcinogens.

4.3 UNCERTAINTY ANALYSIS

Human health risks posed by a defined set of circumstances may be evaluated quantitatively. The precision of these estimates is limited by the size and quality of the data base. Often, these limitations can be overcome by defining a range of extremes. However, there are varying degrees of uncertainty associated with estimating the risks that may result from chemical exposure. These uncertainties have been compensated for throughout the risk assessment by making health-protective assumptions where necessary. Specific elements of uncertainty include the following:

- Fate and transport estimates
- Exposure estimates
- Basis of the mathematical models of exposure assessment
- Toxicological data and risk characterization
- Complex interactions of uncertainty elements

The uncertainty elements and the steps taken to address them are reviewed here.

The exposure scenarios assume that a hypothetical receptor would be continually exposed to a reasonable maximum potential off-site concentration of each type of chemical constituent in groundwater and air or periodically exposed to constituents in soil and air during a trespass scenario.

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4.3.1 Fate and Transport Estimates

Many of the site constituents are subject to attenuation in groundwater, soil and air by such processes as photo-decomposition, sorption, settling, or and biodegradation. The half-life values associated with these fate processes are site-specific and dependent on many environmental factors. Because of the uncertainty associated with measuring these fate processes, the risk assessment assumes that none of these processes is operative, which adds conservatism to the quantitative risk assessment.

4.3.2 Exposure Estimates

The exposure assessment utilizes models that rely on transport through air or groundwater before direct ingestion and other indirect routes of exposure. The assumptions used in the exposure models are discussed in detail in Appendices B through E. These assumptions illustrate the consistently health-protective bias built into the risk assessment to compensate for uncertainty. Where reasonable approximations of the site-specific scenario could not be estimated, conservative "default" values that err on the side of overestimation of exposure were utilized.

4.3.3 Basis for the Mathematical Models of Exposure Assessment

Mathematical models, such as those employed in the exposure assessment, are helpful in providing numerical approximations of a biological system's response given a particular set of input conditions and constraints. The risk assessment models provide predictive estimates of the effects of chemicals in a given biological system (e.g., a child and adult).

Any attempt to model a biological system incorporates some degree of uncertainty. For example, in modeling the transfer of a

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chemical through an inhalation pathway such as a shower inhalation scenario, it is necessary to quantify the chemical transfer rates from water to air and from air to humans. If these values do not exist as a result of previous scientific inquiry, assumptions are made that permit estimation from the best available, most relevant information. The precision of the resulting estimate of dose incurred depends on the accuracy of these assumptions reflecting real-world events.

In essence, the scientist has taken a system in which many variables exist and constructed a manageable model of that system by assuming those variables are constant at a defined level. This approach sets the input chemical concentration as the only independent variable in the model. A linear relationship is assumed that is not necessarily reflective of real-world conditions. The dependent variable (the dose incurred) becomes a function of chemical concentration alone, which may not adequately represent site-specific conditions. This dose is qualified by the constraints on the model.

4.3.4 Toxicological Data and Risk Characterization

The overriding uncertainties associated with the risk characterization are:

- The extrapolation of toxic or carcinogenic effects observed at the high doses necessary to conduct animal studies to effects that might occur at much lower "real world" doses
- The extrapolation from toxic effects in animals to toxic effects in man (i.e., responses of animals may be different from responses of man)

These extrapolations form the basis for the derivation of the factors used to estimate risks. The carcinogenic potency factors

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(CPFs) are derived using a weight-of-evidence approach to studies in the scientific literature. Because of the lack of human epidemiological data for most chemicals, the evidence results from animal studies in which experimental groups were exposed for most of their lifetime to doses many times those normally found in the environment. In some cases, only a single study may be used in this derivation process.

The U.S. EPA uses a prescribed protocol (U.S. EPA, 1989) to evaluate animal data to estimate human cancer potency factors. The linearized multistage extrapolation model is utilized which provides a mathematical approximation of the dose-response slopes. Of the half-dozen equally feasible dose-response extrapolation models available, the one selected by these agencies as applied here is designed to define the highest upper bound risk condition. The results from this model most likely overestimate the actual risk rather than underestimate it. In addition, because the slope estimates are based on animal data, the ratio of cancer potency slopes between chemicals may be more reflective of animal responses than human. In short, because the models do not incorporate the role of biologic protective mechanisms or human epidemiology, they are only gross indicators that are specifically designed to most likely overestimate potential risks.

The necessity of using animal studies is obvious and much valuable information has been gained as a result. However, variations in pharmacokinetics and metabolism occur when identical experiments are carried out using different animal species. These species-to-species variations in responses exacerbate the already difficult task of extrapolating from effects seen in animal studies to predictive effects in humans. In addition, the metabolic or pharmacokinetic idiosyncrasies of a

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given animal model may result in effects that may not be observed in humans because humans may respond to a given chemical differently.

The high doses used in these animal studies also add additional levels of uncertainty. High dose levels may result in saturation effects in certain biochemical systems of an organism. For example, enzyme kinetics are vastly altered at substrate saturation levels. Effects seen at high doses may not be representative of the kinetics of the particular enzyme system under lower-dose, nonsaturated conditions.

Even in cases where there are adequate epidemiological data, uncertainty persists. The exposures in such studies are not controlled in the sense of a laboratory experiment and it is often impossible to isolate an exposure to a specific chemical. Therefore, the effect(s) observed may actually result from the interaction of a mixture of chemicals peculiar to that exposure incident. Unless the potential chemical mixture is fully defined, extrapolation to other exposure scenarios cannot be made without uncertainty.

The risk assessment utilizes the guidance of the U.S. EPA in minimizing the uncertainties by using published standards and criteria to evaluate the risks posed by existing conditions at the site.

4.3.5 Complex Interaction of Uncertainty Elements

A risk assessment of a site is ultimately an integrated evaluation of historical, chemical, analytical, environmental, and toxicological data that are as site-specific as possible. To minimize the effect of uncertainties in the evaluation, each step is biased toward health protective estimations. Since each step

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builds on the previous one, this biased approach more than compensates for risk assessment uncertainties. In addition, these calculations do not represent currently existing or expected future exposures or health risks. Rather, they are estimations that may occur only if all of the conservative assumptions are realized.

5.0 ECOLOGICAL RISK CHARACTERIZATION

The Hranica site is a 15-acre area located on a hilltop off Ekastown Road, near Sarver, in Butler County, Pennsylvania, 21 miles northeast of Pittsburgh. The terrestrial ecosystem of the area is characterized by the presence of deciduous wooded areas, croplands, orchards, and an old field community located on the site itself. An unnamed tributary of Little Bull Creek flows through the site, and a large unnamed tributary of McDowell Creek is located in the area west of the site.

Western Pennsylvania, including Pittsburgh and surrounding areas, is considered part of the Western Allegheny Plateau (Omernik, 1986). The region is characterized by hilly terrain. Omernik (1986) defines the natural vegetation type as mixed mesophytic forest which typically contains maple (Acer), buckeye (Aesculus), beech (Fagus), tuliptree (Liriodendron tulipifera), oak (Quercus), and linden (Tilia).

A vegetative community typical of disturbed areas is found on the site. These communities characteristically contain a large proportion of herbaceous biennial and perennial species including Queen Anne's lace (Daucus carota), teasel (Dipsacus sylvestris), white sweet clover (Melilotus alba), yellow sweet clover (M. officinalis), dandelion (Tavaxacum officinale), milkweed (Aselepias syriaca), chickory (Chichorium intybus), crown vetch (Caronilla varia), goldenrod (Solidago sp.), common ragweed (Ambrosia artemisiifolia), evening primrose (Oenothera biennis), yarrow (Achillea millefolium), pigweed (Amoranthus retroflex), purslane (Portulaca olevacea), black-eyed susan (Rudbeckia hirta), spring beauty (Claytonia virginica), and trillium (Trillium sp.) (Niering and Olmstead, 1979). Crown vetch has

been observed to cover much of the surface of the ash pile which has been covered with a two-foot clayey soil cover (Dunn, 1989).

The presence of wooded areas, open fields, croplands, orchards, and small streams presents a diversity of habitat types which could potentially support a wide diversity of wildlife. Mammal species found in Western Pennsylvania which inhabit such areas include opossum (Didelphis marsupialis), racoon (Procyon lotor), masked shrew (Sorex cinereus), least shrew (Cryptotis parua), hairytail mole (Parascalops breweri), striped skunk (Mephitis mephitis), woodchuck (Marmota monax), red fox (Vulpes fulva), gray fox (Urocyon cinereoargentcus), eastern chipmunk (Tamias striatus), eastern gray squirrel (Sciurus carolinensis), fox squirrel (S. niger), southern flying squirrel (Glaucomys volans), white-footed mouse (Peromyscus leucopus), deer mouse (P. maniculatus), meadow vole (Microtus pennsylvanicus), pine vole (Pitymys pinetorum), eastern cottontail (Sylvilagus floridanus), whitetail deer (Odocoileus virginianus), long-tailed weasel (Mustela frenata), and black bear (Ursus americanus) (Burt and Grossenheider, 1964; Sutton and Sutton, 1985).

Bird species commonly found in this area of Pennsylvania include eastern screech owl (Otus asia), great horned owl (Bubo virginianus), ruffed grouse (Bonasa umbellus), American crow (Corvus brachyrhynchos), mourning dove (Zenaida macroura), pileated woodpecker (Dryocopus pileatus), red-headed woodpecker (Melanerpes erythrocephalus), hairy woodpecker (Picoides villosus), eastern wood pewee (Contopus virens), red-eyed vireo (Vireo olivaceus), yellow-throated vireo (V. flavifrons), American robin (Turdus migratorius), northern oriole (Icterus galbula), northern cardinal (Cardinalis cardinalis), blue jay (Cyanocitta cristata), white-breasted nuthatch (Sitta

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carolinensis), red-winged blackbird (Agelaius phoeniceus), and European starling (Sturnus vulgaris) (Sutton and Sutton, 1985).

Common fish species which would be expected to inhabit the small intermittent stream which flows through the site include fathead minnow (Pimephales promelas), common shiner (Notropis carnatus), white sucker (Catostomus commersoni), and black bullhead (Ictalurus melas).

Chemical constituents found in surface water samples collected from streams and seeps within and proximate to the Hranica site are presented in Table 10 (Dunn, 1989). Aluminum, copper, and zinc were measured at concentrations in excess of water quality criteria (U.S. EPA, 1986) developed for the protection of aquatic life. The elevated concentrations of these three metals are of concern due to the potential threat to forage fish, macroinvertebrates, and other aquatic life expected in the unnamed tributary. However, due to the ephemeral nature of the riparian habitat and its limited potential to support a diverse aquatic community, it is our opinion that potential adverse effects posed by the suboptimum water quality are expected to be insignificant at the population and community level of organization.

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TABLES

TABLE 1
CONSTITUENTS DETECTED IN SITE GROUNDWATER[a]
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

CONSTITUENTS	QUANTIFICATION LIMIT (mg/ℓ)	RANGE OF CONCENTRATIONS (mg/ℓ)	FREQUENCY OF OCCURRENCE	DRINKING WATER STANDARD[b] OR HEALTH ADVISORY (mg/ℓ)	CONSTITUENT OF CONCERN
VOLATILES (VOC)					
Acetone	0.01	ND[c] - 0.57	4/8	NA[d]	Yes
Methylene chloride	0.005	ND - 0.007	1/8	2.0 (DWEL)	No
Toluene	0.005	ND - 0.078	3/8	2.0 (MCL)	No
Benzene	0.005	ND - 0.037	2/8	0.005 (MCL)	Yes
Ethylbenzene	0.005	ND - 0.19	3/8	0.7 (MCL)	No
Total xylenes	0.005	ND - 0.51	3/8	10.0 (MCL)	No
4-Methyl-2-Pentanone (MIBK)	0.01	ND - 0.2	3/8	0.2 (LHA)[e]	Yes
2-Butanone (MEK)	0.01	ND - 0.073	2/8	0.2 (LHA)	Yes
Carbon disulfide	0.005	ND - 0.008	1/8	NA	No
SEMIVOLATILES (SVOC)					
Napthalene	0.01	ND - 0.17	2/6	NA	Yes
2-Methyl napthalene	0.01	ND - 0.17	2/6	NA	No
Dibenzofuran	0.01	ND - 0.028	1/6	NA	No
Bis(ethylhexyl)phthalate (BEHP)	0.01	ND - 0.16	3/6	NA	No
Butylbenzylphthalate	0.01	ND - 0.015	1/6	NA	No
Phenanthrene	0.01	ND - 0.029	1/6	NA	No
2,4-Dimethylphenol	0.01	ND - 0.013	2/6	NA	No
Aldrin	0.00005	ND - 0.00007	1/8	NA	No

See footnotes at end of table.

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TABLE 1
(Continued)

CONSTITUENTS	QUANTIFICATION LIMIT (mg/ℓ)	RANGE OF CONCENTRATIONS (mg/ℓ)	FREQUENCY OF OCCURRENCE	DRINKING WATER STANDARD[b] OR HEALTH ADVISORY (mg/ℓ)	CONSTITUENT OF CONCERN
METALS					
Aluminum	0.2	0.215 - 157	7/7	NA	No
Antimony	0.06	ND - 0.072	1/7	NA	No
Barium	0.2	ND - 4.62	5/7	5.0 (MCL)	No
Beryllium	0.005	ND - 0.0468	2/7	NA	Yes
Cadmium	0.005	ND - 0.0432	2/7	0.005 (MCL)	Yes
Calcium	5.0	ND - 586	5/7	NA	No
Chromium	0.01	ND - 0.228	2/7	0.1 (MCL)	Yes
Cobalt	0.05	ND - 0.409	3/7	NA	No
Copper	0.025	ND - 0.882	2/7	1.3 (MCL)	No
Iron	0.1	ND - 498	6/7	NA	No
Lead	0.005	ND - 0.15	2/7	0.005 (MCL)	Yes
Magnesium	5.0	ND - 104	4/7	NA	No
Manganese	0.015	ND - 21.9	5/7	NA	No
Nickel	0.04	ND - 0.337	3/7	0.6 (DWEL)	Yes
Potassium	5.0	ND - 75.4	4/7	NA	No
Sodium	5.0	154 - 754	7/7	20.0 (DWEL)	No
Vanadium	0.05	ND - 0.354	1/7	NA	No
Zinc	0.02	ND - 2.27	4/7	NA	No
Cyanide	0.01	ND - 0.033	2/7	0.2 (LHA)	No

[a]Compounds from deep monitoring wells; only those found above detection limits presented. Reported levels for metals were derived from filtered monitoring well samples.

[b]DWEL = Drinking Water Equivalent Level.
MCL = Maximum Contaminant Level.
LHA = Lifetime Health Advisory.

[c]ND - Not detected.

[d]NA = Not available.

[e]Health advisory for MEK used as surrogate.

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TABLE 2

CONSTITUENTS DETECTED IN SITE SURFACE SOILS[a]
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

CONSTITUENTS[b]	QUANTIFICATION LIMIT (mg/kg)	RANGE OF CONCENTRATIONS (mg/kg)	FREQUENCY OF OCCURRENCE	NORMALLY OCCURRING[c] BACKGROUND LEVELS (mg/kg)	REFERENCE DOSE OR CPF	CONSTITUENT OF CONCERN
VOLATILES (VOC)						
Toluene	0.005	ND[d] - 0.017	5/14	NA[e]	Yes	Yes
Total xylenes	0.005	ND - 0.205	5/14	NA	Yes	Yes
Tetrachloroethylene	0.005	ND - 0.0247	1/14	NA	Yes	Yes
Trichloroethylene	0.005	ND - 0.006	2/14	NA	Yes	Yes
1,1,1-Trichloroethane	0.005	ND - 0.009	3/14	NA	Yes	Yes
SEMIVOLATILES (SVOC)						
Naphthalene	0.01	ND - 14.1	2/14	NA	Yes	Yes
2-Methyl naphthalene	0.01	ND - 2.36	1/14	NA	No	No
Bis(2-ethylhexyl)phthalate (BEHP)	0.01	ND - 3.10	8/14	NA	Yes	Yes
PESTICIDES/PCBs						
4,4'-DDE	0.008	ND - 0.073	1/14	NA	Yes	No
PCB-1254	0.16	ND - 1.10	1/14	NA	Yes	No
PCB-1260	0.16	ND - 2.60	4/14	NA	Yes	Yes
PCB-1254/1260	0.16	ND - 12.65	4/14	NA	Yes	Yes

See footnotes at end of table.

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TABLE 2
(Continued)

CONSTITUENTS[b]	QUANTIFICATION LIMIT (mg/kg)	RANGE OF CONCENTRATIONS (mg/kg)	FREQUENCY OF OCCURRENCE	NORMALLY OCCURRING[c] BACKGROUND LEVELS (mg/kg)	REFERENCE DOSE OR CPF	CONSTITUENT OF CONCERN
METALS						
Aluminum	20.0	5,490 - 13,900	14/14	33,000 - 120,000	No	No
Antimony	6.0	ND - 17.6	6/14	0.76 - 8.8	Yes	Yes
Arsenic	1.0	2.80 - 9.40	14/14	5.0 - 73.0	Yes	Yes
Barium	20.0	50.0 - 3,470	14/14	290 - 3,000	Yes	Yes
Cadmium	0.5	ND - 374.0	12/14	0.35 - 2.0	Yes	Yes
Chromium	1.0	7.80 - 245.0	14/14	33.0 - 1,000	Yes	Yes
Cobalt	5.0	5.10 - 58.6	14/14	5.9 - 70.0	No	No
Copper	2.5	2.90 - 563	14/14	13.0 - 700	No	No
Lead	0.5	9.10 - 4,774	14/14	10.0 - 200	Yes	Yes
Manganese	1.5	231.0 - 903.0	14/14	260 - 7,000	Yes	Yes
Mercury	0.1	ND - 4.6	14/14	0.05 - 3.4	Yes	Yes
Nickel	4.0	6.10 - 29.95	14/14	11.0 - 1,000	Yes	Yes
Selenium	0.5	ND - 127.0	8/14	0.20 - 12.0	Yes	Yes
Silver	1.0	1.80 - 2.30	14/14	NA	No	No
Thallium	1.0	ND - 1.40	3/14	<50.0	Yes	No
Vanadium	5.0	6.60 - 20.1	14/14	43.0 - 300	Yes	No
Zinc	2.0	38.0 - 2,779	14/14	40.0 - 2,900	Yes	Yes
Cyanide	1.0	ND - 2.80	6/14	NA	Yes	Yes

[a]Dunn Geoscience Corporation, 1989; Borings B2 through B6, B9 through B11, and B13 through B18. Only samples collected from less than 3.0 feet used.

[b]Normally occurring soil elements Ca, Fe, Mg, K, and Na not included.

[c]Dunn Geoscience Corporation, 1989; Ioven, 1989; U.S. EPA, 1985.

[d]ND = Not detected above quantification limit.

[e]NA = Not available.

NOTE: CPF = Cancer Potency Factor.

TABLE 3

CONSTITUENTS DETECTED IN SITE SOIL GAS[a]
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

CONSTITUENTS	QUANTIFICATION LIMIT (µg/ℓ)	RANGE OF CONCENTRATIONS (µg/ℓ)	FREQUENCY OF OCCURRENCE	INHALATION RfD or CPF	CONSTITUENT OF CONCERN
Pentane/MTBE[b]	1.0	ND[c] - 198	25/140	No	No
Benzene	1.0	ND - 32	18/140	Yes	Yes
Toluene	1.0	ND - 4,599	26/140	Yes	Yes
Ethylbenzene	1.0	ND - 24,000	45/140	No	No
Xylenes (Total)	1.0	ND - 70,000	51/140	Yes	Yes

[a]Dunn Geoscience Corporation, 1989.

[b]Methyl Tertiary Butyl Ether.

[c]ND = Not detected above quantification limit.

NOTE: RfD = Reference Dose, CPF = Cancer Potency Factor.

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TABLE 4
CONCENTRATIONS OF INDICATOR CONSTITUENTS
IN SITE SOIL BORINGS COMPARED WITH ASH SAMPLE
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

INDICATOR CONSTITUENTS	ASH PIT AREA[a] (mg/kg)	NON-ASH PIT AREA[b] (mg/kg)	ASH SAMPLE[c] (mg/kg)
Barium	3,035	185.2	1,980
Cadmium	328.6	19.1	100
Chromium	268.5	59.6	645
Lead	5,398	629.7	4,060
Mercury	2.5	1.7	3.2
Selenium	107.1	1.7	4.1

[a]Soil Borings B5, B9, B11, and B17 (most surficial sample only - 0 to 3.0 feet; 95 percent arithmetic upper bound limit; see Appendix A).

[b]Soil Borings B2 to B4, B6, B10, B13 to B16, B18 (most surficial sample only - 0 to 3.0 feet; 95 percent arithmetic upper bound limit; see Appendix A).

[c]D'Appolonia, 1984 (ash sample collected from Hranica Landfill site).

TABLE 5

SUMMARY RISK ESTIMATES FOR GROUNDWATER
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

INCREASED LIFETIME CANCER RISK

	ROUTE OF EXPOSURE			
POPULATION	INGESTION	DERMAL CONTACT	INHALATION	TOTAL
Off-Site Adult	4.1×10^{-7}	3.3×10^{-7}	1.7×10^{-7}	9.1×10^{-7}
Off-Site Child	2.5×10^{-7}	1.9×10^{-7}	2.8×10^{-7}	7.3×10^{-7}

NONCARCINOGENIC HAZARD INDEX

	ROUTE OF EXPOSURE			
POPULATION	INGESTION	DERMAL CONTACT	INHALATION	TOTAL
Off-Site Adult	2.8×10^{-1}	4.8×10^{-2}	7.6×10^{-4}	3.3×10^{-1}
Off-Site Child	2.9×10^{-1}	4.7×10^{-2}	2.1×10^{-3}	3.4×10^{-1}

TABLE 6

SUMMARY RISK ESTIMATES FOR ASH PILE AREA SOILS
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

INCREASED LIFETIME CANCER RISK

	ROUTE OF EXPOSURE		
POPULATION	INGESTION/DERMAL CONTACT	INHALATION	TOTAL
Adult Trespasser	9.8×10^{-6}	5.0×10^{-10}	9.8×10^{-6}
Child Trespasser	7.3×10^{-6}	2.8×10^{-10}	7.3×10^{-6}
Off-Site Adult	NA	1.3×10^{-7}	1.3×10^{-7}
Off-Site Child	NA	2.2×10^{-7}	2.2×10^{-7}

NONCARCINOGENIC HAZARD INDEX

	ROUTE OF EXPOSURE		
POPULATION	INGESTION/DERMAL CONTACT	INHALATION	TOTAL
Adult Trespasser	1.2	0.0004	1.2
Child Trespasser	4.4	0.0011	4.4
Off-Site Adult	NA	0.10	0.10
Off-Site Child	NA	0.29	0.29

NA = Not applicable route of exposure.

TABLE 7

SUMMARY RISK ESTIMATES FOR NON-ASH PILE AREA SOILS
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

INCREASED LIFETIME CANCER RISK

POPULATION	ROUTE OF EXPOSURE		
	INGESTION/DERMAL CONTACT	INHALATION	TOTAL
Adult Trespasser	1.5×10^{-6}	1.70×10^{-10}	1.5×10^{-6}
Child Trespasser	1.1×10^{-6}	9.5×10^{-11}	1.1×10^{-6}
Off-Site Adult	NA	4.6×10^{-8}	4.6×10^{-8}
Off-Site Child	NA	7.6×10^{-8}	7.6×10^{-8}

NONCARCINOGENIC HAZARD INDEX

POPULATION	ROUTE OF EXPOSURE		
	INGESTION/DERMAL CONTACT	INHALATION	TOTAL
Adult Trespasser	0.14	0.000054	0.14
Child Trespasser	0.52	0.00015	0.52
Off-Site Adult	NA	0.014	0.014
Off-Site Child	NA	0.039	0.039

NA = Not applicable route of exposure.

TABLE 8

SUMMARY RISK ESTIMATES FOR SOIL GAS
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

INCREASED LIFETIME CANCER RISK

POPULATION	ROUTE OF EXPOSURE INHALATION
Adult Trespasser	5.4×10^{-10}
Child Trespasser	3.0×10^{-10}
Off-Site Adult	1.4×10^{-7}
Off-Site Child	2.4×10^{-7}

NONCARCINOGENIC HAZARD INDEX

POPULATION	ROUTE OF EXPOSURE INHALATION
Adult Trespasser	2.9×10^{-4}
Child Trespasser	8.0×10^{-4}
Off-Site Adult	7.8×10^{-2}
Off-Site Child	2.2×10^{-1}

TABLE 9

SUMMARY RISK ESTIMATES FOR ALL MEDIA
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

WITH EXPOSURE TO ASH PIT AREA CONSTITUENTS

POPULATION	TOTAL LIFETIME CANCER RISK	TOTAL NONCARCINOGENIC HAZARD INDEX
Adult Trespasser	9.8×10^{-6}	1.2
Child Trespasser	7.3×10^{-6}	4.4
Off-Site Adult	1.2×10^{-6}	0.51
Off-Site Child	1.2×10^{-6}	0.85

WITH EXPOSURE TO NON-ASH PIT AREA CONSTITUENTS

POPULATION	TOTAL LIFETIME CANCER RISK	TOTAL NONCARCINOGENIC HAZARD INDEX
Adult Trespasser	1.5×10^{-6}	0.13
Child Trespasser	1.1×10^{-6}	0.48
Off-Site Adult	1.1×10^{-6}	0.42
Off-Site Child	1.0×10^{-6}	0.60

TABLE 10

CONSTITUENTS DETECTED IN SURFACE WATER[a]
HRANICA SITE
BUFFALO TOWNSHIP, PENNSYLVANIA

CONSTITUENTS	RANGE OF CONCENTRATIONS (mg/ℓ)	1986 WATER QUALITY CRITERIA (FRESHWATER CONCENTRATIONS) ACUTE (mg/ℓ)	CHRONIC (mg/ℓ)
Acetone	ND[b] - 0.017	NA[c]	NA
Methylene Chloride	ND - 0.02	NA	NA
1,2-Dichloroethylene	ND - 0.005	11.60[d]	NA
1,2-Dichloropropane	ND - 0.007	23.0[d]	5.70[d]
Benzyl alcohol	ND - 0.023	NA	NA
Bis(2-ethylhexyl)phthalate	ND - 3.8	NA	NA
Diethyl phthalate	ND - 0.015	NA	NA
Lead	ND - 0.056	0.082[e]	0.003[e]
Nickel	ND - 0.133	1.400[e]	0.160[e]
Zinc	ND - 20.6	0.120[e]	0.110[e]
Aluminum	ND - 0.292	0.15	0.087
Calcium	9.04 - 80.4	NA	NA
Cobalt	ND - 0.156	NA	NA
Copper	ND - 0.118	0.018[e]	0.012[e]
Iron	ND - 0.528	NA	1.0
Magnesium	ND - 21.6	NA	NA
Manganese	ND - 59.3	NA	NA
Potassium	ND - 14.6	NA	NA
Sodium	ND - 24.8	NA	NA

[a]Dunn Geoscience, 1989.

[b]ND = Not detected below quantification limit.

[c]NA = Not available.

[d]Insufficient data to develop criteria.
Value presented is the L.O.E.L. - Lowest Observed Effect Level.

[e]Hardness dependent criteria (100 mg/ℓ used).

NOTE: Only those constituents found above quantification limit are presented.

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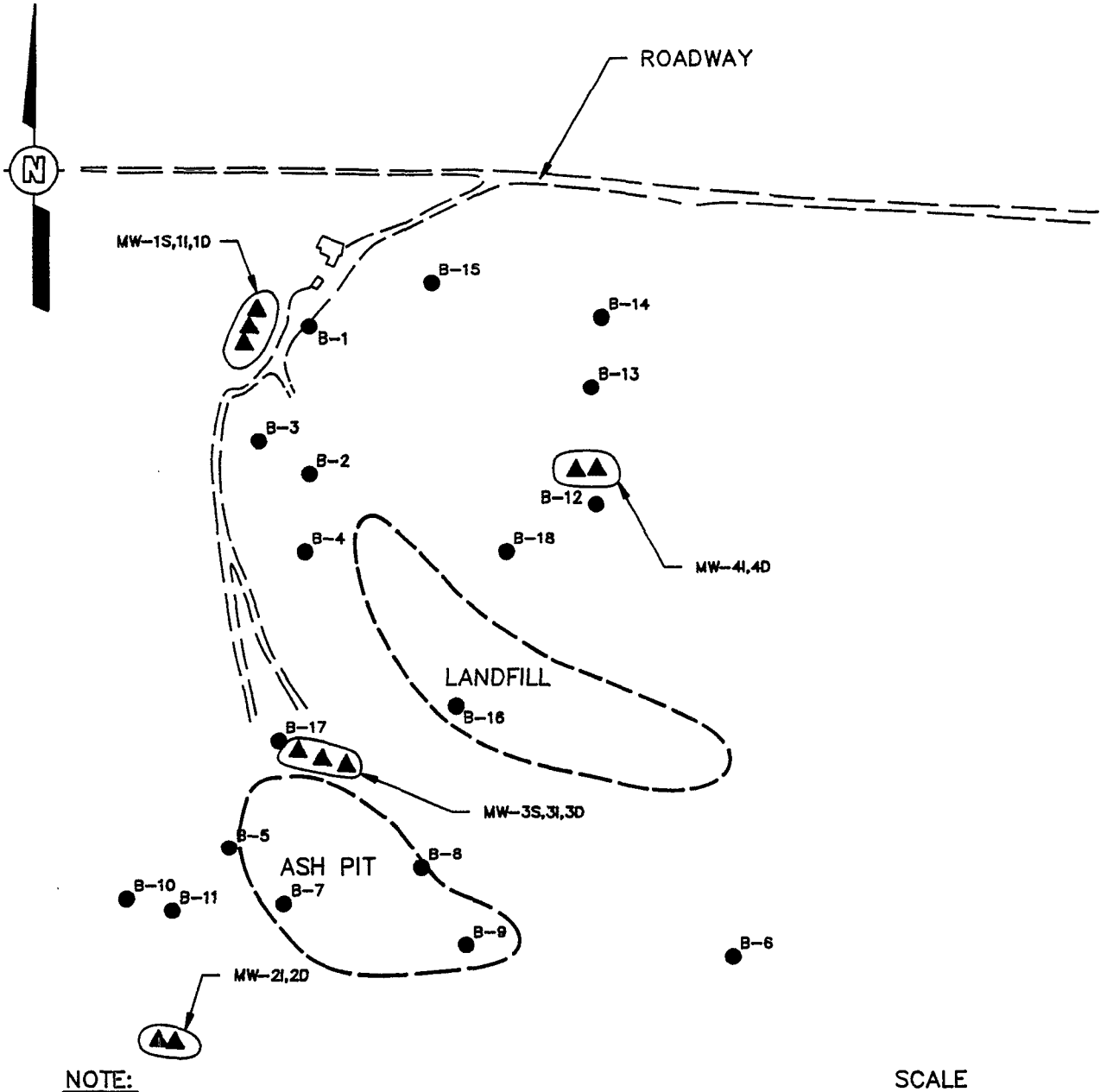
FIGURES

AR301419

DRAWN BY	CHECKED BY	DRAWING NUMBER
KME 3-22-90	APPROVED BY	303776-A1



NOTE:

NON-ASH PIT AREA: SOIL BORINGS B-2 - B-4, B-6, B-10, B-13 - B-16, B-18

ASH PIT AREA: SOIL BORING B-5, B-9, B-11, B-17

BORINGS B-1, B-7, B-8 AND B-12 NOT INCLUDED IN ASH PIT OR NON-ASH PIT AREA BECAUSE ALL SOIL SAMPLES COLLECTED FROM THESE BORINGS WERE FROM DEPTHS GREATER THAN 3.0 FEET (SEE SECTION 3.2).

LEGEND:

B10 SOIL BORING

MW-2D GROUNDWATER CLUSTER WELL

SOURCE:

DUNN GEOSCIENCE, 1989

SCALE

0 200 400 FEET

FIGURE 1

SCHEMATIC MAP SHOWING THE SOIL BORING AND GROUNDWATER MONITORING WELL LOCATIONS

PREPARED FOR

PPG INDUSTRIES INC.
HRANICA LANDFILL SITE

AR301620

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APPENDIX A
INPUT DATA BY MEDIA

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APPENDIX A

INPUT DATA BY MEDIA
HRANICA LANDFILL

CONSTITUENT	CONCENTRATION
Groundwater (mg/ℓ)[a]	
Acetone	0.269
Benzene	0.0155
2-Butanone (MEK)	0.0320
4-Methyl-2-Pentanone (M1BK)	0.0825
Naphthalene	0.0724
Cadmium	0.0217
Beryllium	0.0224
Chromium	0.0998
Lead	0.0658
Nickel	0.245
Soil (Ash Pit Area; mg/kg)[b]	
Antimony	15.24
Arsenic	6.14
Barium	3,035
Cadmium	328.6
Chromium	268.5
Lead	5,398
Manganese	520.7
Mercury	2.50
Nickel	29.57
Selenium	107.1
Zinc	2,839
Cyanide	2.62
Toluene	0.0096
Xylene	0.173
Tetrachloroethylene	0.0211
Trichloroethylene	0.0044
1,1,1-Trichloroethane	0.0061
Naphthalene	11.82
Bis(2-ethylhexyl)phthalate	3.247
PCB (1254/1260)	10.96
Soil (Non-ash Pit Area, mg/kg)[c]	
Antimony	6.78
Arsenic	6.94
Barium	185.2
Cadmium	19.12
Chromium	59.60
Lead	629.7
Manganese	759.0

CONSTITUENT	CONCENTRATION
Soil (Non-ash Pit Area, mg/kg)[c] (Continued)	
Mercury	1.68
Nickel	23.63
Selenium	1.70
Zinc	591.0
Cyanide	1.26
Toluene	0.0087
Xylene	0.021
Tetrachloroethylene	0.0025
Trichloroethylene	0.0035
1,1,1-trichloroethane	0.0050
Naphthalene	0.134
Bis(2-ethylhexyl)phthalate	0.59
PCB (1254/1260)	1.57
Soil Gas (µg/ℓ)[d]	
Benzene	1.81
Toluene	115.5
Xylene (total)	3,637

[a]Groundwater Wells 1D, 2D, 3D, and 4D (duplicates included).

[b]Soil Borings B5, B9, B11, and B17 (most surficial sample only - 0 to 3.0 feet; duplicates included).

[c]Soil Borings B2 to B4, B6, B10, B13 to B16, B18 (most surficial sample only - 0 to 3.0 feet.

[d]Soil-gas probe samples 1 to 140 (duplicates included).

NOTE: All concentrations represent 95 percent arithmetic upper bound limit (data presented in Dunn Geoscience (1989).

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APPENDIX B
VHS MODEL FOR GROUNDWATER TRANSPORT

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APPENDIX B

VHS MODEL FOR GROUNDWATER TRANSPORT

VHS Model from 40 CFR Part 261; Vol. 50, No. 229, Pages 48886-48957.

$$Cy = Co \text{ erf } ((y'/4y)^{0.5} \text{ erf}(X/(4(a_t\ y)^{0.5}))$$

where

y' = 12.2 meters (constant),

y = distance to nearest receptor (meters),

a_t = transverse dispersivity = 2 meters (constant),

Co = initial groundwater/leachate concentrations, and

X = length of contaminated area (meters).

y = 2,000 ft (610 m) from site boundary along groundwater flow path to the nearest private well (i.e., DW-5, George Pajer well), and

X = 600 ft (183 m) based on approximate limits of ash mound and landfill

thus

$$Cy = Co \text{ erf } (0.071) \text{ erf } (1.31)$$

$$Cy = Co\ (0.07998)(0.9361)$$

$$Cy = Co\ (0.07487)$$

Model output is presented in Table B-1.

TABLE B-1

VHS MODEL OUTPUT

CONSTITUENT	CONCENTRATIONS AT POINT OF EXPOSURE (mg/ℓ)
Benzene	0.00118
Acetone	0.0201
MIBK	0.00618
MEK	0.00240
Naphthalene	0.00542
Cadmium	0.00612
Chromium	0.00747
Lead	0.00493
Beryllium	0.00168
Nickel	0.0183

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APPENDIX C
SHOWER INHALATION MODEL

APPENDIX C
SHOWER INHALATION MODEL

INHALATION OF CONTAMINANTS VOLATILIZED FROM SHOWER WATER

In the model developed by Foster and Chrostowski (1986), inhalation exposures to volatile organic chemicals (VOCs) while showering are modeled by estimating the rate of chemical releases into the air (generation rate), the buildup of VOCs in the shower room air while the shower is on, and the decay of VOCs in the shower room air after the shower is turned off, and the quantity of airborne VOCs inhaled while the shower is both on and off.

Estimation of the rate of VOC release into the air is based upon Liss and Slater's (1974) adaptation of the two-film gas-liquid mass transfer theory. The two-film boundary theory provides the basis for estimating the overall mass transfer coefficient (K_L) for each VOC of interest, according to the following equation:

$$K_L = (1/k_l + RT/Hk_g)^{-1} \qquad (1)$$

where

K_L = overall mass transfer coefficient (centimeter per hour [cm/hr]),

H = Henry's law constant (atm-m^3/mol-K),

RT = 2.4×10^{-2} atm-m^3/mole (gas constant of 8.2×10^{-5} atm-^{3}/mole-K times absolute temperature of 293 K),

kg = gas-film mass transfer coefficient (cm/hr), and

k_l = liquid-film mass transfer coefficient (cm/hr).

Equation 1 describes the mass transfer rate of a compound at an air-water interface where diffusion may be limited by both liquid- and gas-phase resistances.

Typical values of k_l (20 cm/hr) and k_g (3,000 cm/hr), which have been measured for CO_2 and H_2O, respectively, may be used to estimate VOC-specific values for these parameters (Liss and Slater, 1974):

$$k_g(VOC) = k_g(H_2O(18/MW_{VOC})^{0.5} \quad (2)$$

$$k_l(VOC) = k_l(CO_2(44/MW_{VOC})^{0.5} \quad (3)$$

where

MW = molecular weight (g/mol).

The mass transfer coefficient, K_L, is adjusted to the shower water temperature, T_s, according to a semi-empirical equation developed to estimate the effect of temperature on oxygen mass-transfer rate (O'Connor and Dobbins, 1956):

$$K_{aL} = K_L(T_l\mu_s/T_s\mu_l)^{-0.5} \quad (4)$$

where

K_{aL} = adjusted overall mass transfer coefficient (cm/hr),
T_l = calibration water temperature of K_L (K),
T_s = shower water temperature (K),
μl = water viscosity at T_l (cp), and
μ_s = water viscosity at T_s (cp).

The concentration leaving the shower droplet, C_{wd}, is obtained from an integrated rate equation based on a mass-balance approach:

$$C_{wd} = C_{w0}(1-\exp[-K_{aL}t_s/60d]) \quad (5)$$

where

C_{wd} = concentration leaving shower droplet after time t_s (µg/ℓ),
C_{w0} = shower water concentration (µg/ℓ),
d = shower droplet diameter (mm), and
t_s = shower droplet drop time (sec).

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The term $K_{aL}/60d$ combines both the rate transfer and the available interfacial area across which volatilization can occur. The value 1/60d equals the specific interfacial area, 6/d, for a special shower droplet of diameter "d" multiplied by conversion factors (hr/3,600 sec and 10 mm/cm).

The VOC generation rate in the shower room, S, can then be calculated by the equation:

$$S = C_{wd}(Fr)/SV \qquad (6)$$

where

S = indoor VOC generation rate ($\mu g/m^3$-min),
FR = shower water flow rate (liter/min), and
SV = shower room air volume (m^3).

A simple one-box indoor air pollution model was used to estimate VOC air concentrations in the shower room. This model can be expressed as a differential equation describing the rate of change of the indoor pollutant concentration with time:

$$dC_a/dt = RC_a + S \qquad (7)$$

where

C_a = indoor VOC air concentrations ($\mu g/m^3$, and
R = air exchange rate (min^{-1}).

When Equation 7 is integrated, the time-dependent indoor concentration can be estimated as follows:

$$C_a(t) = (S/R)(1 - \exp[-Rt]) \text{ for } t \leq D_s$$

and

$$C_a(t) = (S/R)(\exp[RDs] - 1)\exp(-Rt]) \text{ for } t \leq D_s$$

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where

$C_a(t)$ = indoor air VOC concentration at time t ($\mu g/m^3$),
D_s = shower duration (min), and
t = time (min).

The inhalation exposure per shower can then be calculated according to the equation:

$$E_{inh} = [VR/(BW)(10^6)]\int_0^{D_t} C_a(t)dt$$

where

E_{inh} = inhalation exposure per shower (mg/kg/shower),
VR = ventilation rate (liter/min),
BW = body weight (kg), and
D_t = total duration in shower room (min).

This equation can be solved as:

$$E_{inh} = (VR)(S)/[(BW)(R)(10^6)]\ [D_s - 1/R + \exp(-RD_s)/R]$$

for the duration of the shower, and as

$$E_{inh} = (VR)(S)/[(BW)(R)(10^6)] \times \left[[D_s + \frac{\exp(-RD_t)}{R}] - \frac{[\exp[R(D_s - D_t]]}{R}\right]$$

for both the duration of the shower and the duration in the room after the shower is turned off.

Assuming that an individual showers daily, E_{inh} is then equivalent to the chronic daily intake.

AR301434

Table C-1 lists the input parameters to the shower model. Molecular weights and Henry's law constants for the chemicals in question are given in Table C-2 and model outputs are given in Table C-3.

AR301435

LIST OF REFERENCES

Foster, S. A. and P. C. Chrostowski, 1986, Integrated Household Exposure Model for Use of Tap Water Contaminated with Volatile Organic Chemicals, presented at the 79th Annual Meeting of the Air Pollution Control Association, Minneapolis, Minnesota, June 22-27, 1986.

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O'Connor, D. J. and W. Dobbins, 1956, The Mechanics of Reaeration in Natural Streams, J. Sanit, Eng. Div., ASCE 82:SA6, in Schroeder, E. D. Water and Wastewater Treatment, Chapter 4: Gas Transfer, McGraw-Hill, 1977.

TABLE C-1

PARAMETERS USED IN THE CALCULATION OF INTAKES
CAUSED BY VOLATILIZATION DURING SHOWERING

PARAMETER	UNITS	VALUE
Calibration water temperature, T_1	K	293
Shower water temperature, T_s	K	318
Water viscosity at T_1, μ_1	Centipoise	1.002
Water viscosity at T_s, μ_s	Centipoise	0.596
Shower water droplet diameter, d	mm	1.0
Shower droplet drop time, t_s	sec	2
Shower water flow rate, FR	liter/min	10
Shower room air volume, SV	m^3	6
Air exchange rate, R	min^{-1}	0.0083
Shower duration, D_s	min	12
Total duration in shower room, D_t	min	15
Ventilation rate, VR (adult)	liter/min	10
Ventilation rate, VR (child)	liter/min	13.3
Body weight, BW (adult)	kg	70
Body weight, BW (child)	kg	34

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TABLE C-2

PHYSICOCHEMICAL PROPERTIES OF VOCs USED IN THE SHOWER EXPOSURE MODEL

CHEMICAL	MOLECULAR WEIGHT (g/mol)	HENRY'S LAW CONSTANT ($atm\text{-}m^3/mol\text{-}K$)
Benzene	78	5.50×10^{-3}
MIBK	100.2	4.95×10^{-5}
MEK	72.1	2.74×10^{-5}

TABLE C-3

SHOWER MODEL OUTPUT

CHEMICAL/RECEPTOR	INHALATION EXPOSURE PER SHOWER (mg/kg/shower)
Benzene (Adult)	1.36×10^{-5}
Benzene (Child)	3.73×10^{-5}
MIBK (Adult)	1.43×10^{-5}
MIBK (Child)	3.91×10^{-5}
MEK (Adult)	3.96×10^{-6}
MEK (Child)	1.09×10^{-5}

AR301440

APPENDIX D
ATMOSPHERIC MODELS

APPENDIX D

ATMOSPHERIC MODELS

CALCULATIONS FOR DETERMINING PARTICULATE EMISSION RATES FROM VEHICULAR TRAFFIC ON SITE

Equation to be used (U.S. EPA, 1988) is:

$$E_{VT} = (K)\ (5.9)(s/12)\ (Sp/30)\ (W/3)^{0.7}\ (w/4)^{0.5}\ (365\text{-}Dp/365)$$

where

E_{VT} = emission factor in lbs/vehicle mile traveled,

K = particle size multiplier, 0.45 (unitless),

S = silt content of road, taken to be the geometric mean of % silt from soil borings = 20.4%,

Sp = vehicle speed, assumed to be 15 mph for rough, unpaved roads,

W = vehicle weight, assumed to be approximately three tons

w = number of wheels on vehicle is assumed to be four, and

Dp = number of days of rain/year (greater than 0.01 in.), approximately 160 days

then

$$E_{VT} = 0.45\ (5.9)\ (20.4/12)\ (15/30)\ (3/3)^{0.7}\ (4/4)^{0.5}\ (365\text{-}160/365)$$

$$E_{VT} = 1.27 \text{ lbs/vehicle mile}$$

Number of miles per week:

There is approximately 2,000 feet of road. Assuming three round-trip visits (trespasses) by cars per week then there are 2.3 vehicle miles per week.

Emission Rate (converts pounds soil per vehicle mile to g/sec):

$$E_i = \frac{1.27 \text{ lbs}}{\text{vehicle mile}} * \frac{2.3 \text{ vehicle miles}}{\text{week}} * \frac{1 \text{ week}}{7 \text{ days}} * \frac{1 \text{ day}}{24 \text{ hrs}} * \frac{1 \text{ hr}}{3{,}600 \text{ secs}} * \frac{1{,}000 \text{ grams}}{2.2 \text{ lbs}}$$

$E_i = 2.20 \times 10^{-3}$ g soil/sec from vehicular traffic
(or 2.2 mg/sec)

CALCULATIONS FOR DETERMINING PARTICULATE EMISSION RATES FROM WIND EROSION (U.S. EPA, 1984)

Equation

$$E_{10} = 0.83 \text{ (f) } P(u^+) \text{ (1-v)/(PE/50)}^2$$

where

E_{10} = emission factor in mg/m^2-hr,

f = frequency of disturbances/month, assumed to be 15 (No. of days/month which exceed the maximum wind velocity at 7 m), and

$P(u^+)$ = erosion potential in g/m^2, calculated from the equation below:

$$P(u^+) = 6.7(u^+ - u_T)$$

where

u^+ = observed (or probable) fastest mile of wind; 21.6 m/s (U.S. EPA, 1984)

u_T = erosion threshold windspeed of 13 m/s, using an intermediate roughness factor of 3 for grasslands (U.S. EPA, 1984),

v = fraction of contaminated surface area that is vegetated. This is assumed to be 75% or 0.75 from preliminary assessment of available site maps, and

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PE = Precipitation Evaporation Index used as measure of average soil moisture content. A default value of 120 is used.

$$P(u^{+}) = 6.7\ (21.6\text{-}13) = 57.6\ g/m^3$$

then:

$$E_{10} = 0.83\ (15)\ (57.6)\ (1\text{-}0.75)/(120/50)^2 = 31.1\ mg/m^3\text{-}hr$$

Next convert to an emission rate in mg/sec:

$$\frac{31.1\ mg}{m^2\text{-}hr} * \frac{1\ hr}{3{,}600\ sec} * 15\ acres\ for\ site * \frac{4{,}047\ m^2}{1\ acre} =$$

524 mg/sec (for the entire site).

BOX MODEL - TO CALCULATE CONCENTRATIONS IN AIR ON SITE FOR A TRESPASS SCENARIO

$$C_{air} = E_i/r(u)(L)$$

where

C_{air} = concentration of chemical in air in mg/m^3

E_i = emission rate, 524 mg/sec for wind erosion and 2.2 mg/sec for vehicular traffic

r = atmospheric mixing zone, 400 m (U.S. EPA, 1972)

u = average wind speed of 4.2 m/s (NOAA, 1977)

i = length of site based on total area, 250 m.

$$C_{air_{(wind\ erosion)}} = (0.524\ g/s)/(400m)(4.2\ m/s)(250m) = 1.25 \times 10^{-6}\ g/m^3 = 1.25 \times 10^{-3}\ mg/m^3$$

$$C_{air_{(vehicle\ erosion)}} = (2.2 \times 10^{-3} g/s)/(400m)(4.2\ m/s)(250m) = 5.24 \times 10^{-9}\ g/m^3 = 5.24 \times 10^{-6}\ mg/m^3$$

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AIR DISPERSION MODEL CALCULATIONS
(from Turner, 1970)

Assumes a ground level source with no effective plume rise

$$\chi\ (x,o,o;o) = Q/\pi\ y\ z\ u$$

where

χ = concentration of soil particulates at receptor in mg/m^3

Q = emission rate from wind and vehicle erosion in g/sec

y = from nomographs in Turner (in meters)

z = from nomographs in Turner (in meters)

u = average wind speed, 4.2 m/s for Pittsburgh area (U.S. EPA, 1984

$$\chi\ (xo,o;o) = (2.2 \times 10^{-3}\ g/sec + 5.24 \times 10^{-1}\ g/sec)/\pi(66m)(38m)(4.2m/s)$$
$$= 1.59 \times 10^{-5}\ g/m^3\ (g\ of\ soil/m^3)$$

To obtain actual concentrations of chemicals, take the measured concentration in mg/kg and convert to mg of chemical/mg soil. Then multiply this number by the concentrations above (χ) to obtain actual concentrations of a chemical at the receptor point.

e.g., PCE measured concetration = 0.0025 mg/kg

0.0025 mg chemical/kg soil (1 kg soil/10^{-6} mg soil) =
2.5×10^{-6} mg chemical/mg soil

then:

$$2.5 \times 10^{-6}\ mg\ chemical/mg\ soil * 1.59 \times 10^{-2}\ mg\ soil/m^3 =$$

$$3.98 \times 10^{-8}\ \frac{mg\ chemical}{m^3}$$

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LIST OF REFERENCES

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Hannah, S. R., Briggs, G. A. and Hosku, R. P. Jr., 1982, Handbook on Atmospheric Diffusion, Turbulance and Diffusion Laboratory, NOAA.

NOAA, 1977, Local Climatological Data for Pittsburgh, PA, U.S. Department of Commerce, Environmental Data Service.

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APPENDIX E
SOIL-GAS MODELS

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APPENDIX E
SOIL-GAS MODELS

Soil-gas emission rate calculated using:

$$Ei = Ci\ VyA \quad \text{(U.S. EPA, 1988)}$$

where

Ei = emission rate (g/sec),
Ci = constituent concentration in pore space (g/cm^3),
Vy = mean landfill gas velocity (1.63×10^{-3} cm/sec), and
A = area (cm^2).

Area at site = 6.29×10^8 cm^2 based on boundary of soil-gas survey (Dunn, 1989).

Ambient concentration of on-site vapor calculated using the Box Model:

$$C_{AIR} = \frac{Ei}{(r)(u)(L)} \quad \text{(Hanna et al., 1982)}$$

where

C_{AIR} = concentration in air (g/m^3),
Ei = emission rate (g/sec),
r = atmospheric mixing zone set equal to 400 meters (U.S. EPA, 1972),
u = average wind speed in m/sec, and
L = length of soil area (meters).

Average wind speed = 4.2 m/sec (NOAA, 1977).

L = 250 meters (based on total area at site assuming square configuration).

Concentrations off site calculated using Turner's Diffusion Model (Appendix D).

Model output is presented in Table E-1.

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TABLE E-1

SOIL-GAS MODEL OUTPUT

CONSTITUENT	SOIL-GAS CONCENTRATION (µg/ℓ)	EMISSION RATE (g/sec)	ON-SITE ATMOSPHERIC CONCENTRATION (g/m^3)	OFF-SITE ATMOSPHERIC CONCENTRATION (g/m^3)
Benzene	1.81	0.00186	4.42×10^{-9}	5.62×10^{-8}
Toluene	115.5	0.118	2.82×10^{-7}	3.57×10^{-6}
Xylene	3,637	3.73	8.88×10^{-6}	1.13×10^{-4}

NOTE: Off-site concentrations are greater because wind is assumed blowing directly towards receptor 100 percent of the time.

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APPENDIX F

CANCER POTENCY FACTORS AND REFERENCE DOSES USED IN HRANICA LANDFILL RISK CHARACTERIZATION

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APPENDIX F

CANCER POTENCY FACTORS AND REFERENCE DOSES USED IN HRANICA SITE RISK CHARACTERIZATION

CONSTITUENTS	CPF [(mg/kg/day)$^{-1}$]^{a}		RfD (mg/kg/day)^{b}		REFERENCE^{c}
	ORAL	INHALATION	ORAL	INHALATION	
VOLATILES (VOC)					
Acetone	-	-	0.1	-	1
Tetrachloroethylene	0.051	0.0033	0.01	-	1
Benzene	0.029	0.0292	-	-	1
Toluene	-	-	0.3	2.0	1
Xylene	-	-	2.0	0.3	1
4-Methyl-2-pentanone	-	-	0.05	0.02	1
2-Butanone	-	-	0.05	0.09	1
Trichloroethylene	0.011	0.0172	-	-	1
1,1,1-Trichloroethane	-	-	0.09	0.3	1
SEMIVOLATILES (SVOC)					
Naphthalene	-	-	0.4	-	1
Bis(2-ethylhexyl) phthalate	0.014	-	0.02	-	1
PCBs					
PCB-1254/1260	7.7	-	-	-	1
METALS					
Antimony	-	-	0.0004	-	1
Arsenic	0.175^{d}	50	0.001	-	1
Barium	-	-	0.05	0.0001	1
Beryllium	-	8.4	0.005	-	1
Cadmium	-	6.1	0.001^{e}	-	1
Cadmium	-	-	0.0005^{f}	-	1
Chromium	-	41	0.005	-	1
Lead	-	-	0.0014^{g}	-	2
Manganese	-	-	0.2	0.0003	1
Mercury	-	-	0.0003	-	1
Nickel	-	0.84	0.02	-	1

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APPENDIX F
(Continued)

CONSTITUENTS	CPF [(mg/kg/day)$^{-1}$][a] ORAL	CPF [(mg/kg/day)$^{-1}$][a] INHALATION	RfD (mg/kg/day)[b] ORAL	RfD (mg/kg/day)[b] INHALATION	REFERENCE[c]
METALS (Continued)					
Selenium	-	-	0.003	0.001	1
Zinc	-	-	0.2	-	1
Cyanide	-	-	0.02	-	1

[a]CPF = Cancer Potency Factor for carcinogenic effects.

[b]RfD = Reference dose for noncarcinogenic effects.

[c]Reference 1 = Health Effects Assessment Summary, U.S. EPA, 1989, 3rd Quarter. Reference 2 = Derived from lifetime health advisory of 20 µg/day using body weight = 14 kg (U.S. EPA Drinking Water Health Advisory, 1985).

[d]Derived from unit risk of 5×10^{-5} µg/ℓ using body weight of 70 kg, ingestion rate of 2 ℓ/day, and benchmark cancer risk of 1×10^{-5}. A benchmark cancer risk one order of magnitude less conservative than 1×10^{-6} is appropriate for oral exposure from arsenic due to the uncertainties associated with ingested inorganic arsenic (IRIS, 1990; Section II.B).

[e]Represents oral RFD for food for soil ingestion exposure pathway.

[f]Represents oral RFD for water for water ingestion exposure pathway.

[g]The RFD for lead has been suspended because it is currently believed by the U.S. EPA that for young children, no exposure to lead is acceptable. Although cancer potency factors are unavailable as yet, lead is considered to be a Probable Human Carcinogen via the oral and inhalation routes.

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APPENDIX G

TEMPLATES USED IN CALCULATING CARCINOGENIC AND NONCARCINOGENIC RISK AT THE HRANICA SITE

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APPENDIX G

TEMPLATES USED IN CALCULATING CARCINOGENIC AND NONCARCINOGENIC RISK AT THE HRANICA SITE

TABLE NO.	DESCRIPTION
1	Ingestion of chemical constituents in groundwater, residential exposure scenario, adult receptor
2	Ingestion of chemical constituents in groundwater, residential exposure scenario, child receptor
3	Inhalation of volatilized groundwater chemical constituents during showering, carcinogenic effects, adult/child receptor
4	Inhalation of volatilized groundwater chemical constituents during showering, noncarcinogenic effects, adult/child receptor
5	Dermal contact with chemical constituents in groundwater, residential showering scenario, adult receptor
6	Dermal contact with chemical constituents in groundwater, residential showering scenario, child receptor
7	Ingestion of and dermal contact with chemical constituents in ash pit area soils, trespass scenario, adult receptor
8	Ingestion of and dermal contact with chemical constituents in ash pit area soils, trespass scenario, child receptor
9	Ingestion of and dermal contact with chemical constituents in non-ash pit area soils, trespass scenario, adult receptor
10	Ingestion of and dermal contact with chemical constituents in non-ash pit area soils, trespass scenario, child receptor
11	Inhalation of air particulates mobilized from ash pit area soils, trespass scenario, adult/child receptors, carcinogenic effects.

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APPENDIX G
(Continued)

12 Inhalation of air particulates mobilized from ash pit area soils, trespass scenario, adult/child receptors, noncarcinogenic effects.

13 Inhalation of air particulates mobilized from ash pit area soils, residential exposure scenario, adult/child receptors, carcinogenic effects.

14 Inhalation of air particulates mobilized from ash pit area soils, residential exposure scenario, adult/child receptors, noncarcinogenic effects.

15 Inhalation of air particulates mobilized from non-ash pit area soils, trespass scenario, adult/child receptors, carcinogenic effects.

16 Inhalation of air particulates mobilized from non-ash pit area soils, trespass scenario, adult/child receptors, noncarcinogenic effects.

17 Inhalation of air particulates mobilized from non-ash pit area soils, residential exposure scenario, adult/child receptors, carcinogenic effects.

18 Inhalation of air particulates mobilized from non-ash pit area soils, residential exposure scenario, adult/child receptors, noncarcinogenic effects.

19 Inhalation of soil gas generated from the entire site, trespass scenario, adult/child receptors, carcinogenic effects.

20 Inhalation of soil gas generated from the entire site, trespass scenario, adult/child receptors, noncarcinogenic effects.

21 Inhalation of soil gas generated from the entire site, residential exposure scenario, adult/child receptors, carcinogenic effects.

22 Inhalation of soil gas generated from the entire site, residential exposure scenario, adult/child receptors, noncarcinogenic effects.

GWINGAHR.WK1 383776-01 Site Name: HRANICA LANDFILL
04/03/98 Ingestion of Chemical Constituents in Groundwater
Residential Exposure Scenario
Receptor: ADULT

This table calculates estimated body dose, incremental cancer risk, and hazard indices from oral exposure to chemical constituents in water.

The equations used to calculate body doses, incidental cancer rates, and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

$$\text{Cancer Rate} = \text{Body Dose (mg/kg/day)} \times \text{Cancer Potency Factor (mg/kg/day)}^{-1}$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
IR = INGESTION RATE (l/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged [days]).

Constituent	"CW" Concentration (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq (days/year)	"BW" Body Weight (kg)	"L" Lifetime (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Body Dose (mg/kg/day)	CPF (mg/kg/day)-1	Oral Cancer Risk	Standard/ Guideline (RfD) (mg/kg/day)	"HI" Hazard Index
BENZENE (CARCINOGEN)	1.16E-03	2.0	365	70.0	70	25550	30.0	1.42E-05	2.90E-02	4.12E-07	0.00E+00	ERR
MIBK (NONCARCINOGEN)	6.18E-03	2.0	365	70.0	30	10950	30.0	1.77E-04	0.00E+00	0.00E+00	5.00E-02	3.53E-03
CADMIUM (NONCARCINOGEN)	1.62E-03	2.0	365	70.0	30	10950	30.0	4.63E-05	0.00E+00	0.00E+00	5.00E-04	9.26E-02
CHROMIUM (NONCARCINOGEN)	7.47E-03	2.0	365	70.0	30	10950	30.0	2.13E-04	0.00E+00	0.00E+00	5.00E-03	4.27E-02
LEAD (NONCARCINOGEN)	4.96E-03	2.0	365	70.0	30	10950	30.0	1.42E-04	0.00E+00	0.00E+00	1.40E-03	1.01E-01
ACETONE (NONCARCINOGEN)	2.01E-02	2.0	365	70.0	30	10950	30.0	5.74E-04	0.00E+00	0.00E+00	1.00E-01	5.74E-03
MEK (NONCARCINOGEN)	2.40E-03	2.0	365	70.0	30	10950	30.0	6.86E-05	0.00E+00	0.00E+00	5.00E-02	1.37E-03
NAPHTHALENE (NONCARCINOGEN)	5.42E-03	2.0	365	70.0	30	10950	30.0	1.55E-04	0.00E+00	0.00E+00	4.00E-01	3.87E-04
BERYLLIUM (NONCARCINOGEN)	1.68E-03	2.0	365	70.0	30	10950	30.0	4.80E-05	0.00E+00	0.00E+00	5.00E-03	9.60E-03
NICKEL (NONCARCINOGEN)	1.83E-02	2.0	365	70.0	30	10950	30.0	5.23E-04	0.00E+00	0.00E+00	2.00E-02	2.61E-02
									SUMMATION:	4.12E-07		2.83E-01

REFERENCES FOR ASSUMPTIONS:

BODY WEIGHT (USEPA, 1989 [HWEM]).
INGESTION (95TH PERCENTILE; USEPA, 1989 [HWEM]).
CONSTITUENT CONCENTRATIONS REPRESENT 95% UPPER BOUND OF ARITHMETIC VALUES FROM DEEP GROUNDWATER MONITORING WELLS, MODELED TO THE NEAREST PRIVATE WELL USING THE VHS MODEL.

Table 1

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GWINGCHR.WK1 383776-01 Site Name: HRANICA LANDFILL
04/03/90 Ingestion of Chemical Constituents in Groundwater
Residential Exposure Scenario
Receptor: CHILD

This table calculates estimated body dose, incremental cancer risk, and hazard indices from oral exposure to chemical constituents in water.

The equations used to calculate body doses, incidental cancer rates, and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

$$\text{Cancer Rate} = \text{Body Dose (mg/kg/day)} \times \text{Cancer Potency Factor (mg/kg/day)}^{-1}$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
IR = INGESTION RATE (l/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged [days]).

Constituent	"CW" Concentration (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq (days/year)	"BW" Body Weight (kg)	"L" Lifetime (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Body Dose (mg/kg/day)	CPF (mg/kg/day)-1	Oral Cancer Risk	Standard/ Guideline (RfD) (mg/kg/day)	"HI" Hazard Index
BENZENE (CARCINOGEN)	1.16E-03	1.0	365	34.0	70	25550	18.0	8.77E-06	2.90E-02	2.54E-07	0.00E+00	ERR
MIBK (NONCARCINOGEN)	6.18E-03	1.0	365	34.0	18	6570	18.0	1.82E-04	0.00E+00	0.00E+00	5.00E-02	3.64E-03
CADMIUM (NONCARCINOGEN)	1.62E-03	1.0	365	34.0	18	6570	18.0	4.76E-05	0.00E+00	0.00E+00	5.00E-04	9.53E-02
CHROMIUM (NONCARCINOGEN)	7.47E-03	1.0	365	34.0	18	6570	18.0	2.20E-04	0.00E+00	0.00E+00	5.00E-03	4.39E-02
LEAD (NONCARCINOGEN)	4.96E-03	1.0	365	34.0	18	6570	18.0	1.46E-04	0.00E+00	0.00E+00	1.40E-03	1.04E-01
ACETONE (NONCARCINOGEN)	2.01E-02	1.0	365	34.0	18	6570	18.0	5.91E-04	0.00E+00	0.00E+00	1.00E-01	5.91E-03
MEK (NONCARCINOGEN)	2.40E-03	1.0	365	34.0	18	6570	18.0	7.06E-05	0.00E+00	0.00E+00	5.00E-02	1.41E-03
NAPHTHALENE (NONCARCINOGEN)	5.42E-03	1.0	365	34.0	18	6570	18.0	1.59E-04	0.00E+00	0.00E+00	4.00E-01	3.99E-04
BERYLLIUM (NONCARCINOGEN)	1.68E-03	1.0	365	34.0	18	6570	18.0	4.94E-05	0.00E+00	0.00E+00	5.00E-03	9.88E-03
NICKEL (NONCARCINOGEN)	1.83E-02	1.0	365	34.0	18	6570	18.0	5.38E-04	0.00E+00	0.00E+00	2.00E-02	2.69E-02
									SUMMATION:	2.54E-07		2.92E-01

REFERENCES FOR ASSUMPTIONS:

BODY WEIGHT (USEPA, 1989 [HHEM]).
INGESTION (95TH PERCENTILE; USEPA, 1989 [HHEM]).
CONSTITUENT CONCENTRATIONS REPRESENT 95% UPPER BOUND OF ARITHMETIC VALUES FROM DEEP GROUNDWATER MONITORING WELLS, MODELED TO THE NEAREST PRIVATE WELL USING THE VHS MODEL.

Table 2

AR301461

PN = 383776-01 Site Name: HRANICA LANDFILL
H2OINHCA Inhalation of Volatilized Groundwater Constituents During Showering
23-Mar-98 Carcinogenic Effects
Receptor: ADULT/CHILD

This table calculates estimated body dose and incremental cancer risks.

The equations used to calculate body doses and incidental cancer rates are:

Body Dose = (SD * EF * ED) / AT
(mg/kg/day)

Cancer Rate = Body Dose (mg/kg/day) * Cancer Potency Factor (mg/kg/day)^-1

WHERE:
SD = CONSTITUENT DOSE FROM SHOWER (mg/kg/shower)
EF = EXPOSURE FREQUENCY (showers/year)
ED = EXPOSURE DURATION (years)
AT = AVERAGING TIME (lifetime over which exposure is averaged - days)

Compound	"SD" Shower Dose (mg/kg/shower)	"EF" Exposure Freq. (showers/yr)	"ED" Exp. Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	CPF (mg/kg/d)^-1	Incremental Carcinogenic Risk
Benzene (child)	3.73E-05	365	10	70.0	25550	9.59E-06	2.92E-02	2.80E-07
Benzene (adult)	1.36E-05	365	30	70.0	25550	5.83E-06	2.92E-02	1.70E-07

TOTAL CANCER RISK-ADULT	1.70E-07
TOTAL CANCER RISK-CHILD	2.80E-07

REFERENCES FOR ASSUMPTIONS: SHOWER DOSE FROM SHOWER MODEL.

AR301452

Table 3

PN = 303776-1 Site Name: HRANICA LANDFILL

H2OINHNC Inhalation of Volatilized Groundwater Constituents During Showering

23-Mar-90 Noncarcinogenic Effects

Receptor: ADULT/CHILD

This table calculates estimated body dose and hazard indices.

The equations used to calculate body doses and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = (SD \times EF \times ED) / AT$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Reference Dose (mg/kg/day)}}$$

WHERE:

SD = CONSTITUENT DOSE FROM SHOWER (mg/kg/shower)

EF = EXPOSURE FREQUENCY (showers/year)

ED = EXPOSURE DURATION (years)

AT = AVERAGING TIME (lifetime over which exposure is averaged - days)

Compound	"SD" Shower Dose (mg/kg/shower)	"EF" Exposure Freq. (showers/yr)	"ED" Exp. Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	Reference Dose (mg/kg/day)	Hazard Index
MIBK (child)	3.91E-05	365	10	10.0	6570	3.91E-05	0.02	1.96E-03
MIBK (adult)	1.43E-05	365	30	30.0	10950	1.43E-05	0.02	7.15E-04
MEK (child)	1.09E-05	365	10	10.0	6570	1.09E-05	0.09	1.21E-04
MEK (adult)	3.96E-06	365	30	30.0	10950	3.96E-06	0.09	4.40E-05

TOTAL HAZARD INDEX-ADULT	7.59E-04
TOTAL HAZARD INDEX-CHILD	2.08E-03

REFERENCES FOR ASSUMPTIONS: SHOWER DOSE FROM SHOWER MODEL.

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Table 4

GWDMLHHR.WK1 383776-01 Site Name: HRAMICA LANDFILL
04/03/98 Dermal Contact with Chemical Constituents in Groundwater
Residential Showering Exposure Scenario
Receptor: ADULT

This table calculates estimated body dose, incremental cancer risk, and hazard indices from dermal exposure to chemical constituents in water.

The equations used to calculate body doses, incidental cancer rates, and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CFv}{BW \times AT}$$

$$\text{Cancer Rate} = \text{Body Dose (mg/kg/day)} \times \text{Cancer Potency Factor (mg/kg/day)}^{-1}$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
SA = SKIN SURFACE AREA (cm^2)
PC = CHEMICAL-SPECIFIC DERMAL PERMEABILITY CONSTANT (cm/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
CFv = VOLUMETRIC CONVERSION FACTOR (0.001 liters/1000 cm^3)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged [days])

Constituent	"CW" Concentration (mg/l)	"SA" Skin Area (cm^2)	"ET" Exp. Time (hr/day)	"PC" Perm. Constant (cm/hr)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	"L" Lifetime (years)	"AT" Averaging Time (days)	"ED" Exp. Duration (years)	Body Dose (mg/kg/day)	CPF (mg/kg/day)-1	Dermal Cancer Risk	Standard/ Guideline (Rfd) (mg/kg/day)	"HI" Hazard Index
BENZENE (CARCINOGEN)	1.16E-03	19400	0.2	4.10E-01	365	70.0	70	25550	30.0	1.13E-05	2.90E-02	3.28E-07	0.00E+00	ERR
MIBK (NONCARCINOGEN)	6.18E-03	19400	0.2	5.00E+00	365	70.0	30	10950	30.0	1.71E-03	0.00E+00	0.00E+00	5.00E-02	3.43E-02
ACETONE (NONCARCINOGEN)	2.01E-02	19400	0.2	8.00E-04	365	70.0	30	10950	30.0	8.91E-07	0.00E+00	0.00E+00	1.00E-01	8.91E-06
MEK (NONCARCINOGEN)	2.40E-03	19400	0.2	5.00E+00	365	70.0	30	10950	30.0	6.65E-04	0.00E+00	0.00E+00	5.00E-02	1.33E-02
NAPHTHALENE (NONCARCINOGEN)	5.42E-03	19400	0.2	6.00E-04	365	70.0	30	10950	30.0	2.48E-07	0.00E+00	0.00E+00	4.00E-01	6.01E-07
											SUMMATION:	3.28E-07		4.76E-02

REFERENCES FOR ASSUMPTIONS:

EXPOSURE PERIOD FOR SHOWERING (90 PERCENTILE; USEPA, 1989 [HHEM])
SKIN AREA (50TH PERCENTILE; USEPA, 1989 [HHEM])

Table 5

AR301464

GWDMLCHR.WK1 383776-01
04/03/90

Site Name: HRANICA LANDFILL
Dermal Contact with Chemical Constituents in Groundwater
Residential Showering Exposure Scenario
Receptor: CHILD

This table calculates estimated body dose, incremental cancer risk, and hazard indices from dermal exposure to chemical constituents in water.

The equations used to calculate body doses, incidental cancer rates, and hazard indices are:

Body Dose = (CW * SA * PC * ET * EF * ED * CFv)/(BW * AT)
(mg/kg/day)

Cancer Rate = Body Dose (mg/kg/day) * Cancer Potency Factor (mg/kg/day)^-1

Hazard Index = Body Dose (mg/kg/day) / Standard or Guideline (mg/kg/day)

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
SA = SKIN SURFACE AREA (cm^2)
PC = CHEMICAL-SPECIFIC DERMAL PERMEABILITY CONSTANT (cm/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
CFv = VOLUMETRIC CONVERSION FACTOR (0.001 liters/1000 cm^3)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged [days])

Constituent	"CW" Concentration (mg/l)	"SA" Skin Area (cm^2)	"ET" Exp. Time (hr/day)	"PC" Perm. Constant (cm/hr)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	"L" Lifetime (years)	"AT" Averaging Time (days)	"ED" Exp. Duration (years)	Body Dose (mg/kg/day)	CPF (mg/kg/day)-1	Dermal Cancer Risk	Standard/ Guideline (RfD) (mg/kg/day)	"HI" Hazard Index
BENZENE (CARCINOGEN)	1.16E-03	9310	0.2	4.10E-01	365	34.0	70	25550	18.0	6.78E-06	2.90E-02	1.94E-07	0.00E+00	ERR
MIBK (NONCARCINOGEN)	6.18E-03	9310	0.2	5.00E+00	365	34.0	18	6570	18.0	1.69E-03	0.00E+00	0.00E+00	5.00E-02	3.38E-02
ACETONE (NONCARCINOGEN)	2.81E-02	9310	0.2	8.00E-04	365	34.0	18	6570	18.0	8.81E-07	0.00E+00	0.00E+00	1.00E-01	8.81E-06
MEK (NONCARCINOGEN)	2.40E-03	9310	0.2	5.00E+00	365	34.0	18	6570	18.0	6.57E-04	0.00E+00	0.00E+00	5.00E-02	1.31E-02
NAPHTHALENE (NONCARCINOGEN)	5.42E-03	9310	0.2	8.00E-04	365	34.0	18	6570	18.0	2.37E-07	0.00E+00	0.00E+00	4.00E-01	5.94E-07
											SUMMATION:	1.94E-07		4.70E-02

REFERENCES FOR ASSUMPTIONS:

EXPOSURE PERIOD FOR SHOWERING (90 PERCENTILE; USEPA, 1989 [HHEM])
SKIN AREA (50TH PERCENTILE; USEPA, 1989 [HHEM])

Table 6

AR301465

SLAHRWC

04/03/90

PH=3B3776-01

Site Name: HRAHICA LANDFILL - SURFACE SOILS (<3 FT)
Ingestion of and dermal contact with chemical constituents
in soil during on-site trespass scenario
Receptor: ADULT
ASH PIT AREA ONLY (BORINGS B5, B9, B11, B17)

This table calculates estimated body dose, incremental cancer risk, and hazard indices for ingestion of and dermal contact with soil constituents

The equations used to calculate body doses, incidental cancer rates, and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = \frac{CS \times [(IR \times FI) + (SA \times AF \times ABS)] \times CF \times EF \times ED}{(BW \times AT)}$$

$$\text{Cancer Rate} = \text{Body Dose (mg/kg/day)} \times \text{Cancer Potency Factor (mg/kg/day)}^{-1}$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
- CS = CONCENTRATION OF CONSTITUENT IN SOIL (mg/kg)
- IR = INGESTION RATE (mg/day)
- FI = FRACTION INGESTED FROM CONTAMINATED SOURCE (100%)
- SA = SKIN SURFACE AREA (cm^2)
- AF = SOIL TO SKIN ADHERENCE FACTOR (mg/cm^2/day)
- ABS = DERMAL ABSORPTION FACTOR (unitless)
- CF = CONVERSION FACTOR (10^-6 kg/mg)
- EF = EXPOSURE FREQUENCY (days/year)
- ED = EXPOSURE DURATION (years)
- BW = BODY WEIGHT (kg)
- AT = AVERAGING TIME (period over which exposure is average [days])

Constituent	"CS" Concentration (mg/kg)	"IR" Ingest. Rate (mg/day)	"FI" Fraction Ing. (unitless)	"SA" Skin Area (cm^2)	"AF" Adherence Fac. (mg/cm^2/day)	"ABS" Derm. Abs. (unitless)	"EF" Exp. Freq. (days/yr)	"ED" Exp. Duration (years)	"BW" BODY WT. (kg)	Lifetime (years)	"AT" Averaging Time (days)	Body Dose (Ingestion) (mg/kg/day)	Body Dose (Dermal) (mg/kg/day)	Body Dose (Total) (mg/kg/day)
ANTIMONY	15.24	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	3.10E-06	9.68E-07	4.07E-06
ARSENIC (NONCARCINOGEN)	6.14	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.25E-06	3.90E-07	1.64E-06
ARSENIC (CARCINOGEN)	6.14	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	5.36E-07	1.67E-07	7.03E-07
BARIUM	3835.00	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	6.18E-04	1.93E-04	8.10E-04
CADMIUM	328.60	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	6.69E-05	2.09E-05	8.77E-05
CHROMIUM	268.50	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	5.46E-05	1.70E-05	7.17E-05
LEAD	5398.00	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.10E-03	3.43E-04	1.44E-03
MANGANESE	520.70	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.06E-04	3.31E-05	1.39E-04
MERCURY	2.50	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	5.09E-07	1.59E-07	6.68E-07
NICKEL	29.57	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	6.02E-06	1.88E-06	7.90E-06
SELENIUM	107.85	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	2.18E-05	6.80E-06	2.86E-05
ZINC	2839.00	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	5.78E-04	1.80E-04	7.58E-04
CYANIDE	2.62	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	5.33E-07	1.66E-07	7.00E-07
TOLUENE	0.0096	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.95E-09	6.10E-10	2.56E-09
TOTAL XYLENE	0.1734	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	3.53E-08	1.10E-08	4.63E-08
PCE (CARCINOGEN)	0.1734	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	1.51E-08	4.72E-09	1.98E-08
PCE (NONCARCINOGEN)	0.0211	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	4.29E-09	1.34E-09	5.63E-09
TCE (CARCINOGEN)	0.0044	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	3.84E-10	1.20E-10	5.04E-10
1,1,1-TCA	0.0061	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.24E-09	3.87E-10	1.63E-09
NAPHTHALENE	11.6200	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	2.41E-06	7.51E-07	3.16E-06
BEHP (CARCINOGEN)	3.2470	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	2.83E-07	8.84E-08	3.72E-07
BEHP (NONCARCINOGEN)	3.2470	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	6.61E-07	2.06E-07	8.67E-07
PCB (CARCINOGEN)	10.9600	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	9.56E-07	2.98E-07	1.25E-06

REFERENCES FOR ASSUMPTIONS:
INGESTION ABSORPTION = 100 PERCENT.
HEAST, 1989 (3RD QUARTER) FOR CPF AND RfD VALUES; PB RfD FROM SPHEN, 1986.
DERMAL ABSORPTION FROM POIGER AND SCHLATTER, 1980.
SOIL INGESTION RATE FROM LAGOY, 1987.
BODY WEIGHT (USEPA, 1989 [EFH])
SOIL CONTACT RATES FROM SCHAUM, 1984.
SKIN AREA (USEPA, 1989 [HHEM]. HANDS AND ARMS - 50TH PERCENTILE.

Table 7

AR301496

SLAHRWC

04/03/90

PN=383776-01

This table calculates estimated

The equations used to calculate

Body Dose = (CS * [(IR * FI) +
(mg/kg/day)

WHERE:
CS = CONCENTRATION OF CONST
IR = INGESTION RATE (mg/day
FI = FRACTION INGESTED FROM
SA = SKIN SURFACE AREA (cm²

Constituent	Standard/ Guideline (RfD) (mg/kg/day)	(CPF) (mg/kg/day)-1	"HI" HAZARD INDEX	CANCER RISK
ANTIMONY	4.00E-04	0.00E+00	1.02E-02	0.00E+00
ARSENIC (NONCARCINOGEN)	1.00E-03	0.00E+00	1.64E-03	0.00E+00
ARSENIC (CARCINOGEN)	NA	1.75E-01	0.00E+00	1.23E-07
BARIUM	5.00E-02	0.00E+00	1.62E-02	0.00E+00
CADMIUM	1.00E-03	0.00E+00	8.77E-02	0.00E+00
CHROMIUM	5.00E-03	0.00E+00	1.43E-02	0.00E+00
LEAD	1.40E-03	0.00E+00	1.03E+00	0.00E+00
MANGANESE	2.00E-01	0.00E+00	6.95E-04	0.00E+00
MERCURY	3.00E-04	0.00E+00	2.23E-03	0.00E+00
NICKEL	2.00E-02	0.00E+00	3.95E-04	0.00E+00
SELENIUM	3.00E-03	0.00E+00	9.53E-03	0.00E+00
ZINC	2.00E-01	0.00E+00	3.79E-03	0.00E+00
CYANIDE	2.00E-02	0.00E+00	3.58E-05	0.00E+00
TOLUENE	3.00E-01	0.00E+00	8.54E-09	0.00E+00
TOTAL XYLENE	2.00E+00	0.00E+00	2.32E-08	0.00E+00
PCE (CARCINOGEN)	NA	5.10E-02	0.00E+00	1.01E-09
PCE (NONCARCINOGEN)	1.00E-02	0.00E+00	5.63E-07	0.00E+00
TCE (CARCINOGEN)	NA	1.10E-02	0.00E+00	5.54E-12
1,1,1-TCA	9.00E-02	0.00E+00	1.81E-08	0.00E+00
NAPHTHALENE	4.00E-01	0.00E+00	7.09E-06	0.00E+00
BEHP (CARCINOGEN)	NA	1.40E-02	0.00E+00	5.20E-09
BEHP (NONCARCINOGEN)	2.00E-02	0.00E+00	0.00E+00	0.00E+00
PCB (CARCINOGEN)	NA	7.70E+00	0.00E+00	9.66E-06
		SUMMATION:	1.18E+00	9.79E-06

REFERENCES FOR ASSUMPTIONS:

Table 7 continued

AR301467

SLCHRWC

04/03/90

PN=383776-01

Site Name: HRANICA LANDFILL - SURFACE SOILS (3 FT)
Ingestion of and dermal contact with chemical constituents
in soil during on-site trespass scenario
Receptor: CHILD
ASH PIT AREA ONLY (BORINGS B5, B9, B11, B17)

This table calculates estimated body dose, incremental cancer risk, and hazard indices for ingestion of and dermal contact with soil constituents

The equations used to calculate body doses, incidental cancer rates, and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = \frac{CS \times [(IR \times FI) + (SA \times AF \times ABS)] \times CF \times EF \times ED}{BW \times AT}$$

$$\text{Cancer Rate} = \text{Body Dose (mg/kg/day)} \times \text{Cancer Potency Factor (mg/kg/day)}^{-1}$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
- CS = CONCENTRATION OF CONSTITUENT IN SOIL (mg/kg)
- IR = INGESTION RATE (mg/day)
- FI = FRACTION INGESTED FROM CONTAMINATED SOURCE (100%)
- SA = SKIN SURFACE AREA (cm^2)
- AF = SOIL TO SKIN ADHERENCE FACTOR (mg/cm^2/day)
- ABS = DERMAL ABSORPTION FACTOR (unitless)
- CF = CONVERSION FACTOR (10^-6 kg/mg)
- EF = EXPOSURE FREQUENCY (days/year)
- ED = EXPOSURE DURATION (years)
- BW = BODY WEIGHT (kg)
- AT = AVERAGING TIME (period over which exposure is average [days])

Constituent	"CS" Concentration (mg/kg)	"IR" Ingest. Rate (mg/day)	"FI" Fraction Ing. (unitless)	"SA" Skin Area (cm^2)	"AF" Adherence Fac. (mg/cm^2/day)	"ABS" Derm. Abs. (unitless)	"EF" Exp. Freq. (days/yr)	"ED" Exp. Duration (years)	"BW" BODY WT. (kg)	Lifetime (years)	"AT" Averaging Time (days)	Body Dose (Ingestion) (mg/kg/day)	Body Dose (Dermal) (mg/kg/day)	Body Dose (Total) (mg/kg/day)
ANTIMONY	15.24	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.28E-05	2.50E-06	1.53E-05
ARSENIC (NONCARCINOGEN)	6.14	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	5.15E-06	1.01E-06	6.15E-06
ARSENIC (CARCINOGEN)	6.14	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	4.41E-07	8.62E-08	5.27E-07
BARIUM	3835.00	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	2.54E-03	4.97E-04	3.04E-03
CADMIUM	328.50	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	2.75E-04	5.38E-05	3.29E-04
CHROMIUM	268.50	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	2.25E-04	4.40E-05	2.69E-04
LEAD	5390.00	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	4.52E-03	8.84E-04	5.41E-03
MANGANESE	520.70	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	4.36E-04	8.53E-05	5.22E-04
MERCURY	2.50	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	2.10E-06	4.10E-07	2.50E-06
NICKEL	29.57	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	2.48E-05	4.84E-06	2.96E-05
SELENIUM	187.85	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	8.97E-05	1.75E-05	1.07E-04
ZINC	2839.00	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	2.38E-03	4.65E-04	2.84E-03
CYANIDE	2.62	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	2.20E-06	4.29E-07	2.62E-06
TOLUENE	0.0096	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	8.05E-09	1.57E-09	9.62E-09
TOTAL XYLENE	0.1734	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.45E-07	2.84E-08	1.74E-07
PCE (CARCINOGEN)	0.1734	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	1.25E-08	2.44E-09	1.49E-08
PCE (NONCARCINOGEN)	0.0211	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.77E-08	3.46E-09	2.11E-08
TCE (CARCINOGEN)	0.0044	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	3.16E-10	6.18E-11	3.78E-10
1,1,1-TCA	0.0061	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	5.11E-09	9.99E-10	6.11E-09
NAPHTHALENE	11.0200	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	9.91E-06	1.94E-06	1.18E-05
BENP (CARCINOGEN)	3.2470	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	2.33E-07	4.56E-08	2.79E-07
BENP (NONCARCINOGEN)	3.2470	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	2.72E-06	5.32E-07	3.25E-06
PCB (CARCINOGEN)	10.9600	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	7.87E-07	1.54E-07	9.41E-07

REFERENCES FOR ASSUMPTIONS:
INGESTION ABSORPTION = 100 PERCENT.
HEAST, 1989 (3RD QUARTER) FOR CPF AND RfD VALUES; PB RfD FROM SPHEM, 1986.
DERMAL ABSORPTION FROM POTGER AND SCHLATTER, 1980.
SOIL INGESTION RATE FROM LAGOY, 1987.
BODY WEIGHT (USEPA, 1989 [EFH])
SOIL CONTACT RATES FROM SCHAUM, 1984.
SKIN AREA (USEPA, 1989 [HHEM]. HANDS, LEGS AND ARMS - 50TH PERCENTILE.

AR301468

Table 8

SLCHRNC

04/03/90

PN=383776-01

This table calculates estimated

The equations used to calculate

Body Dose = (CS * [(IR * FI) +
(mg/kg/day)

WHERE:
CS = CONCENTRATION OF CONST
IR = INGESTION RATE (mg/day
FI = FRACTION INGESTED FROM
SA = SKIN SURFACE AREA (cm^

Constituent	Standard/ Guideline (RfD) (mg/kg/day)	(CPF) (mg/kg/day)-1	"HI" HAZARD INDEX	CANCER RISK
ANTIMONY	4.00E-04	0.00E+00	3.82E-02	0.00E+00
ARSENIC (NONCARCINOGEN)	1.00E-03	0.00E+00	6.15E-03	0.00E+00
ARSENIC (CARCINOGEN)	NA	1.75E-01	0.00E+00	9.23E-08
BARIUM	5.00E-02	0.00E+00	6.88E-02	0.00E+00
CADMIUM	1.00E-03	0.00E+00	3.29E-01	0.00E+00
CHROMIUM	5.00E-03	0.00E+00	5.38E-02	0.00E+00
LEAD	1.40E-03	0.00E+00	3.86E+00	0.00E+00
MANGANESE	2.00E-01	0.00E+00	2.61E-03	0.00E+00
MERCURY	3.00E-04	0.00E+00	8.35E-03	0.00E+00
NICKEL	2.00E-02	0.00E+00	1.48E-03	0.00E+00
SELENIUM	3.00E-03	0.00E+00	3.58E-02	0.00E+00
ZINC	2.00E-01	0.00E+00	1.42E-02	0.00E+00
CYANIDE	2.00E-02	0.00E+00	1.31E-04	0.00E+00
TOLUENE	3.00E-01	0.00E+00	3.21E-08	0.00E+00
TOTAL XYLENE	2.00E+00	0.00E+00	6.69E-08	0.00E+00
PCE (CARCINOGEN)	NA	5.10E-02	0.00E+00	7.59E-10
PCE (NONCARCINOGEN)	1.00E-02	0.00E+00	2.11E-06	0.00E+00
TCE (CARCINOGEN)	NA	1.10E-02	0.00E+00	4.16E-12
1,1,1-TCA	9.00E-02	0.00E+00	6.79E-08	0.00E+00
NAPHTHALENE	4.00E-01	0.00E+00	2.96E-05	0.00E+00
DEHP (CARCINOGEN)	NA	1.40E-02	0.00E+00	3.90E-09
DEHP (NONCARCINOGEN)	2.00E-02	0.00E+00	0.00E+00	0.00E+00
PCB (CARCINOGEN)	NA	7.70E+00	0.00E+00	7.25E-06
		SUMMATION:	4.41E+00	7.34E-06

REFERENCES FOR ASSUMPTIONS:

Table 8 continued

AR301469

SLAMRP

04/03/90

PN=383776-01

Site Name: HKANICA LANDFILL - SURFACE SOILS ((3 FT)
Ingestion of and dermal contact with chemical constituents
in soil during on-site trespass scenario
Receptor: ADULT
NON-ASH PIT AREA ONLY (BORINGS B2-B4, B6, B18, B13-B16, B18).

This table calculates estimated body dose, incremental cancer risk, and hazard indices for ingestion of and dermal contact with soil constituents

The equations used to calculate body doses, incidental cancer rates, and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = (CS \times ((IR \times FI) + (SA \times AF \times ABS)) \times CF \times EF \times ED)/(BW \times AT)$$

$$\text{Cancer Rate} = \text{Body Dose (mg/kg/day)} \times \text{Cancer Potency Factor (mg/kg/day)}^{-1}$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
- CS = CONCENTRATION OF CONSTITUENT IN SOIL (mg/kg)
- IR = INGESTION RATE (mg/day)
- FI = FRACTION INGESTED FROM CONTAMINATED SOURCE (100%)
- SA = SKIN SURFACE AREA (cm^2)
- AF = SOIL TO SKIN ADHERENCE FACTOR (mg/cm^2/day)
- ABS = DERMAL ABSORPTION FACTOR (unitless)
- CF = CONVERSION FACTOR (10^-6 kg/mg)
- EF = EXPOSURE FREQUENCY (days/year)
- ED = EXPOSURE DURATON (years)
- BW = BODY WEIGHT (kg)
- AT = AVERAGING TIME (period over which exposure is average [days])

Constituent	"CS" Concentration (mg/kg)	"IR" Ingest. Rate (mg/day)	"FI" Fraction Ing. (unitless)	"SA" Skin Area (cm^2)	"AF" Adherence Fac. (mg/cm^2/day)	"ABS" Derm. Abs. (unitless)	"EF" Exp. Freq. (days/yr)	"ED" Exp. Duration (years)	"BW" BODY WT. (kg)	Lifetime (years)	"AT" Averaging Time (days)	Body Dose (Ingestion) (mg/kg/day)	Body Dose (Dermal) (mg/kg/day)	Body Dose (Total) (mg/kg/day)
ANTIMONY	6.78	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.38E-06	4.31E-07	1.81E-06
ARSENIC (NONCARCINOGEN)	6.94	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.41E-06	4.41E-07	1.85E-06
ARSENIC (CARCINOGEN)	6.94	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	6.05E-07	1.89E-07	7.94E-07
BARIUM	165.24	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	3.77E-05	1.18E-05	4.95E-05
CADMIUM	19.12	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	3.89E-06	1.21E-06	5.11E-06
CHROMIUM	59.60	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.21E-05	3.78E-06	1.59E-05
LEAD	629.70	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.28E-04	4.00E-05	1.68E-04
MANGANESE	759.00	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.54E-04	4.82E-05	2.03E-04
MERCURY	1.68	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	3.42E-07	1.07E-07	4.49E-07
NICKEL	23.63	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	4.81E-06	1.50E-06	6.31E-06
SELENIUM	1.70	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	3.46E-07	1.08E-07	4.54E-07
ZINC	591.00	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.20E-04	3.75E-05	1.58E-04
CYANIDE	1.26	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	2.56E-07	8.00E-08	3.36E-07
TOLUENE	0.0007	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.77E-09	5.52E-10	2.32E-09
TOTAL XYLENE	0.0210	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	4.27E-09	1.33E-09	5.61E-09
PCE (CARCINOGEN)	0.0025	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	2.18E-10	6.80E-11	2.86E-10
PCE (NONCARCINOGEN)	0.0025	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	5.09E-10	1.59E-10	6.68E-10
TCE (CARCINOGEN)	0.0035	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	3.05E-10	9.52E-11	4.01E-10
1,1,1-TCA	0.0050	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.02E-09	3.17E-10	1.34E-09
NAPHTHALENE	0.1340	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	2.73E-08	8.51E-09	3.58E-08
BEHP (CARCINOGEN)	0.5900	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	5.15E-08	1.61E-08	6.75E-08
BEHP (NONCARCINOGEN)	0.5900	100.00	1.0	3120	1.0	0.01	52	30	70.0	30	10,950	1.20E-07	3.75E-08	1.58E-07
PCB (CARCINOGEN)	1.5700	100.00	1.0	3120	1.0	0.01	52	30	70.0	70	25,550	1.37E-07	4.27E-08	1.80E-07

REFERENCES FOR ASSUMPTIONS:
INGESTION ABSORPTION = 100 PERCENT.
HEAST, 1989 (3RD QUARTER) FOR CPF AND RfD VALUES; PB RfD FROM SPHEM, 1986.
DERMAL ABSORPTION FROM POIGER AND SCHLATTER, 1980.
SOIL INGESTION RATE FROM LAGOY, 1987.
BODY WEIGHT (USEPA, 1989 [EFH])
SOIL CONTACT RATES FROM SCHAUM, 1984.
SKIN AREA (USEPA, 1989 [EHEM]. HANDS AND ARMS - 50TH PERCENTILE.

AR301470

Table 9

SLAHRAP

04/03/98

PN=383776-01

This table calculates estimated

The equations used to calculate

Body Dose = {CS * [(IR * FI) +
(mg/kg/day)

WHERE:
CS = CONCENTRATION OF CONST
IR = INGESTION RATE (mg/day
FI = FRACTION INGESTED FROM
SA = SKIN SURFACE AREA (cm^

Constituent	Standard/ Guideline (RfD) (mg/kg/day)	(CPF) (mg/kg/day)-1	"HI" HAZARD INDEX	CANCER RISK
ANTIMONY	4.00E-04	0.00E+00	4.53E-03	0.00E+00
ARSENIC (NONCARCINOGEN)	1.00E-03	0.00E+00	1.85E-03	0.00E+00
ARSENIC (CARCINOGEN)	NA	1.75E-01	0.00E+00	1.39E-07
BARIUM	5.00E-02	0.00E+00	9.89E-04	0.00E+00
CADMIUM	1.00E-03	0.00E+00	5.11E-03	0.00E+00
CHROMIUM	5.00E-03	0.00E+00	3.18E-03	0.00E+00
LEAD	1.40E-03	0.00E+00	1.28E-01	0.00E+00
MANGANESE	2.00E-01	0.00E+00	1.81E-03	0.00E+00
MERCURY	3.00E-04	0.00E+00	1.50E-03	0.00E+00
NICKEL	2.00E-02	0.00E+00	3.15E-04	0.00E+00
SELENIUM	3.00E-03	0.00E+00	1.51E-04	0.00E+00
ZINC	2.00E-01	0.00E+00	7.89E-04	0.00E+00
CYANIDE	2.00E-02	0.00E+00	1.68E-05	0.00E+00
TOLUENE	3.00E-01	0.00E+00	7.74E-09	0.00E+00
TOTAL XYLENE	2.00E+00	0.00E+00	2.00E-09	0.00E+00
PCE (CARCINOGEN)	NA	5.10E-02	0.00E+00	1.46E-11
PCE (NONCARCINOGEN)	1.00E-02	0.00E+00	6.66E-08	0.00E+00
TCE (CARCINOGEN)	NA	1.10E-02	0.00E+00	4.41E-12
1,1,1-TCA	9.00E-02	0.00E+00	1.48E-08	0.00E+00
NAPHTHALENE	4.00E-01	0.00E+00	8.95E-08	0.00E+00
BEHP (CARCINOGEN)	NA	1.40E-02	0.00E+00	9.45E-10
BEHP (NONCARCINOGEN)	2.00E-02	0.00E+00	0.00E+00	0.00E+00
PCB (CARCINOGEN)	NA	7.70E+00	0.00E+00	1.38E-06
		SUMMATION:	1.40E-01	1.52E-06

REFERENCES FOR ASSUMPTIONS:

Table 9 continued

AR301471

SLCHRMP

04/03/98

PN=383776-01

Site Name: HKANICA LANDFILL - SURFACE SOILS ((3 FT)
Ingestion of and dermal contact with chemical constituents
in soil during on-site trespass scenario
Receptor: CHILD
NON-ASH PIT AREA ONLY (BORINGS B2-B4, B6, B10, B13-B16, B18).

This table calculates estimated body dose, incremental cancer risk, and hazard indices for ingestion of and dermal contact with soil constituents

The equations used to calculate body doses, incidental cancer rates, and hazard indices are:

Body Dose = (CS * [(IR * FI) + (SA * AF * ABS)] * CF * EF * ED)/(BW * AT)
(mg/kg/day)

Cancer Rate = Body Dose (mg/kg/day) * Cancer Potency Factor (mg/kg/day)^-1

Hazard Index = Body Dose (mg/kg/day) / Standard or Guideline (mg/kg/day)

WHERE:
CS = CONCENTRATION OF CONSTITUENT IN SOIL (mg/kg)
IR = INGESTION RATE (mg/day)
FI = FRACTION INGESTED FROM CONTAMINATED SOURCE (100%)
SA = SKIN SURFACE AREA (cm^2)
AF = SOIL TO SKIN ADHERENCE FACTOR (mg/cm^2/day)
ABS = DERMAL ABSORPTION FACTOR (unitless)
CF = CONVERSION FACTOR (10^-6 kg/mg)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is average [days])

Constituent	"CS" Concentration (mg/kg)	"IR" Ingest. Rate (mg/day)	"FI" Fraction Ing. (unitless)	"SA" Skin Area (cm^2)	"AF" Adherence Fac. (mg/cm^2/day)	"ABS" Derm. Abs. (unitless)	"EF" Exp. Freq. (days/yr)	"ED" Exp. Duration (years)	"BW" BODY WT. (kg)	Lifetime (years)	"AT" Averaging Time (days)	Body Dose (Ingestion) (mg/kg/day)	Body Dose (Dermal) (mg/kg/day)	Body Dose (Total) (mg/kg/day)
ANTIMONY	6.70	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	5.68E-06	1.11E-06	6.79E-06
ARSENIC (NONCARCINOGEN)	6.94	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	5.82E-06	1.14E-06	6.95E-06
ARSENIC (CARCINOGEN)	6.94	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	4.99E-07	9.75E-08	5.96E-07
BARIUM	185.24	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.55E-04	3.03E-05	1.86E-04
CADMIUM	19.12	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.60E-05	3.13E-06	1.92E-05
CHROMIUM	59.60	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	4.99E-05	9.76E-06	5.97E-05
LEAD	629.70	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	5.28E-04	1.03E-04	6.31E-04
MANGANESE	759.00	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	6.36E-04	1.24E-04	7.60E-04
MERCURY	1.60	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.41E-06	2.75E-07	1.68E-06
NICKEL	23.63	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.98E-05	3.87E-06	2.37E-05
SELENIUM	1.70	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.42E-06	2.79E-07	1.70E-06
ZINC	591.00	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	4.95E-04	9.68E-05	5.92E-04
CYANIDE	1.26	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.06E-06	2.06E-07	1.26E-06
TOLUENE	0.0087	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	7.29E-09	1.43E-09	8.72E-09
TOTAL XYLENE	0.0210	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.76E-08	3.44E-09	2.10E-08
PCE (CARCINOGEN)	0.0025	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	1.88E-10	3.51E-11	2.15E-10
PCE (NONCARCINOGEN)	0.0025	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	2.10E-09	4.10E-10	2.50E-09
TCE (CARCINOGEN)	0.0035	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	2.51E-10	4.92E-11	3.01E-10
1,1,1-TCA	0.0050	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	4.19E-09	8.19E-10	5.01E-09
NAPHTHALENE	0.1340	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	1.12E-07	2.20E-08	1.34E-07
BENP (CARCINOGEN)	0.5900	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	4.24E-08	8.29E-09	5.07E-08
BENP (NONCARCINOGEN)	0.5900	200.00	1.0	3910	1.0	0.01	52	6	34.0	6	2,190	4.94E-07	9.67E-08	5.91E-07
PCB (CARCINOGEN)	1.5700	200.00	1.0	3910	1.0	0.01	52	6	34.0	70	25,550	1.13E-07	2.20E-08	1.35E-07

REFERENCES FOR ASSUMPTIONS:
INGESTION ABSORPTION = 100 PERCENT.
HEAST, 1989 (3RD QUARTER) FOR CPF AND RfD VALUES; PB RfD FROM SPHEM, 1986.
DERMAL ABSORPTION FROM POTGER AND SCHLATTER, 1988.
SOIL INGESTION RATE FROM LAGOY, 1987.
BODY WEIGHT (USEPA, 1989 EEFH))
SOIL CONTACT RATES FROM SCHAUM, 1984.
SKIN AREA (USEPA, 1989 EHHEM). HANDS, LEGS AND ARMS - 50TH PERCENTILE.

Table 10

AR301472

SLCHRM

04/03/90

PN=383776-01

This table calculates estimated

The equations used to calculate

Body Dose = (CS * [(IR * FI) +
(mg/kg/day)

WHERE:
CS = CONCENTRATION OF CONST
IR = INGESTION RATE (mg/day
FI = FRACTION INGESTED FROM
SA = SKIN SURFACE AREA (cm²

Constituent	Standard/ Guideline (RfD) (mg/kg/day)	(CPF) (mg/kg/day)-1	"HI" HAZARD INDEX	CANCER RISK
ANTIMONY	4.00E-04	0.00E+00	1.78E-02	0.00E+00
ARSENIC (NONCARCINOGEN)	1.00E-03	0.00E+00	6.95E-03	0.00E+00
ARSENIC (CARCINOGEN)	NA	1.75E-01	0.00E+00	1.04E-07
BARIUM	5.00E-02	0.00E+00	3.71E-03	0.00E+00
CADMIUM	1.00E-03	0.00E+00	1.92E-02	0.00E+00
CHROMIUM	5.00E-03	0.00E+00	1.19E-02	0.00E+00
LEAD	1.40E-03	0.00E+00	4.51E-01	0.00E+00
MANGANESE	2.00E-01	0.00E+00	3.88E-03	0.00E+00
MERCURY	3.00E-04	0.00E+00	5.61E-03	0.00E+00
NICKEL	2.00E-02	0.00E+00	1.18E-03	0.00E+00
SELENIUM	3.00E-03	0.00E+00	5.60E-04	0.00E+00
ZINC	2.00E-01	0.00E+00	2.96E-03	0.00E+00
CYANIDE	2.00E-02	0.00E+00	6.31E-05	0.00E+00
TOLUENE	3.00E-01	0.00E+00	2.91E-06	0.00E+00
TOTAL XYLENE	2.00E+00	0.00E+00	1.05E-06	0.00E+00
PCE (CARCINOGEN)	NA	5.10E-02	0.00E+00	1.09E-11
PCE (NONCARCINOGEN)	1.00E-02	0.00E+00	2.50E-07	0.00E+00
TCE (CARCINOGEN)	NA	1.10E-02	0.00E+00	3.31E-12
1,1,1-TCA	9.00E-02	0.00E+00	5.57E-06	0.00E+00
NAPHTHALENE	4.00E-01	0.00E+00	3.36E-07	0.00E+00
BEHP (CARCINOGEN)	NA	1.40E-02	0.00E+00	7.09E-10
BEHP (NONCARCINOGEN)	2.00E-02	0.00E+00	0.00E+00	0.00E+00
PCB (CARCINOGEN)	NA	7.70E+00	0.00E+00	1.04E-06
		SUMMATION:	5.24E-01	1.14E-06

REFERENCES FOR ASSUMPTIONS:

Table 10 continued

AR301473

AIRCAON1

03-Apr-98

Site Name: HRANICA LANDFILL
Inhalation of Air Particulates: On-site tresspass scenario
Carcinogenic Effects: Worst Case Scenario (ASH-PILE AREA)
Receptor: ADULT/CHILD

This table calculates estimated body doses and incremental cancer risks.

The equations to calculate body dose level and incidental cancer rates are:

Body Dose = CA * IR * ET * EF * ED/ (BW * AT)
(mg/kg/day)

Cancer Rate = Body Dose (mg/kg/day) * Cancer Potency Factor (mg/kg/day)^-1

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	CPF (mg/kg/d)^-1	Incremental Carcinogenic Risk
PERCHLOROETHYLENE (adult)	2.65E-11	0.60000	8.00	70.0000	52	30.0	70.0	25550	1.11E-13	3.30E-03	3.66E-16
PERCHLOROETHYLENE (child)	2.65E-11	0.80000	8.00	34.0000	52	6.0	70.0	25550	6.09E-14	3.30E-03	2.01E-16
TRICHLOROETHYLENE (adult)	5.52E-12	0.60000	8.00	70.0000	52	30.0	70.0	25550	2.31E-14	1.72E-02	1.34E-12
TRICHLOROETHYLENE (child)	5.52E-12	0.80000	8.00	34.0000	52	6.0	70.0	25550	1.27E-14	1.72E-02	7.38E-13
ARSENIC (adult)	7.74E-09	0.60000	8.00	70.0000	52	30.0	70.0	25550	3.24E-11	5.00E+01	6.48E-13
ARSENIC (child)	7.74E-09	0.80000	8.00	34.0000	52	6.0	70.0	25550	1.78E-11	5.00E+01	3.56E-13
CADMIUM (adult)	4.13E-07	0.60000	8.00	70.0000	52	30.0	70.0	25550	1.73E-09	6.10E+00	2.83E-10
CADMIUM (child)	4.13E-07	0.80000	8.00	34.0000	52	6.0	70.0	25550	9.49E-10	6.10E+00	1.56E-10
CHROMIUM (adult)	3.38E-07	0.60000	8.00	70.0000	52	30.0	70.0	25550	1.42E-09	4.10E+01	3.45E-11
CHROMIUM (child)	3.38E-07	0.80000	8.00	34.0000	52	6.0	70.0	25550	7.77E-10	4.10E+01	1.89E-11
NICKEL (adult)	3.72E-08	0.60000	8.00	70.0000	52	30.0	70.0	25550	1.56E-10	8.40E-01	1.85E-10
NICKEL (child)	3.72E-08	0.80000	8.00	34.0000	52	6.0	70.0	25550	8.55E-11	8.40E-01	1.02E-10

TOTAL CANCER RISK-ADULT	5.05E-10
TOTAL CANCER RISK-CHILD	2.77E-10

REFERENCES FOR ASSUMPTIONS: INHALATION (USEPA, 1989 [EFH1]), AIR CONCENTRATIONS FROM BOX MODEL, SEE CALC. SHEETS.

Table 11

AR301474

AIRNCON1 03-Apr-90

Site Name: HRANICA LANDFILL
Inhalation of Air Particulates: On-site tresspass scenario
Noncarcinogenic Effects: Worst Case Scenario (ASH PIT AREA)
Receptor: Adult/Child

This table calculates estimated body doses and hazard indices.

The equations to calculate body dose level and hazard indices are:

Body Dose (mg/kg/day) = CA * IR * ET * EF * ED/ (BW * AT)

Hazard Index = Body Dose (mg/kg/day) / Standard or Guideline (mg/kg/day)

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	Standard/ Guideline (mg/kg/day)	Hazard Index
Toluene (Adult)	1.21E-11	0.60000	8.00	70.0000	52	30.0	30.0	10950	1.18E-13	2.00E+00	5.91E-14
Toluene (Child)	1.21E-11	0.80000	8.00	34.0000	52	6.0	6.0	2190	3.24E-13	2.00E+00	1.62E-13
Xylene (Adult)	2.17E-10	0.60000	8.00	70.0000	52	30.0	30.0	10950	2.12E-12	3.00E-01	7.07E-12
Xylene (Child)	2.17E-10	0.80000	8.00	34.0000	52	6.0	6.0	2190	5.82E-12	3.00E-01	1.94E-11
1,1,1-TCA (adult)	7.66E-12	0.60000	8.00	70.0000	52	30.0	30.0	10950	7.48E-14	3.00E-01	2.49E-13
1,1,1-TCA (child)	7.66E-12	0.80000	8.00	34.0000	52	6.0	6.0	2190	2.05E-13	3.00E-01	6.85E-13
BARIUM (adult)	3.82E-06	0.60000	8.00	70.0000	52	30.0	30.0	10950	3.73E-08	1.00E-04	3.73E-04
BARIUM (child)	3.82E-06	0.80000	8.00	34.0000	52	6.0	6.0	2190	1.02E-07	1.00E-04	1.02E-03
MANGANESE (adult)	6.54E-07	0.60000	8.00	70.0000	52	30.0	30.0	10950	6.39E-09	3.00E-04	2.13E-05
MANGANESE (child)	6.54E-07	0.80000	8.00	34.0000	52	6.0	6.0	2190	1.75E-08	3.00E-04	5.85E-05
SELENIUM (adult)	1.34E-07	0.60000	8.00	70.0000	52	30.0	30.0	10950	1.31E-09	1.00E-03	1.31E-06
SELENIUM (child)	1.34E-07	0.80000	8.00	34.0000	52	6.0	6.0	2190	3.59E-09	1.00E-03	3.59E-06
									TOTAL HAZARD INDEX-ADULT		3.96E-04
									TOTAL HAZARD INDEX-CHILD		1.09E-03

REFERENCES FOR ASSUMPTIONS: INHALATION RATE (USEPA, 1989 [EFH]), AIR CONCENTRATIONS FROM BOX MODEL, SEE CALC SHEETS

Table 12

AR301475

AIRCA2
03-Apr-98

Site Name: HRANICA LANDFILL
Inhalation of Air Particulates in a Residential Setting
Carcinogenic Effects: Worst Case Scenario (ASH PIT AREA)
Receptor: ADULT/CHILD

This table calculates estimated body doses and incremental cancer risks.

The equations to calculate body dose level and incidental cancer rates are:

$$\text{Body Dose (mg/kg/day)} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

$$\text{Cancer Rate} = \text{Body Dose (mg/kg/day)} \times \text{Cancer Potency Factor (mg/kg/day)}^{-1}$$

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	CPF (mg/kg/d)^-1	Incremental Carcinogenic Risk
PERCHLOROETHYLENE (adult)	3.35E-10	0.60000	24.00	70.0000	365	30.0	70.0	25550	2.95E-11	3.30E-03	9.75E-14
PERCHLOROETHYLENE (child)	3.35E-10	0.80000	24.00	34.0000	365	10.0	70.0	25550	4.86E-11	3.30E-03	1.61E-13
TRICHLOROETHYLENE (adult)	7.00E-11	0.60000	24.00	70.0000	365	30.0	70.0	25550	6.17E-12	1.72E-02	3.59E-10
TRICHLOROETHYLENE (child)	7.00E-11	0.80000	24.00	34.0000	365	10.0	70.0	25550	1.02E-11	1.72E-02	5.91E-10
ARSENIC (adult)	9.76E-08	0.60000	24.00	70.0000	365	30.0	70.0	25550	8.60E-09	5.00E+01	1.72E-10
ARSENIC (child)	9.76E-08	0.80000	24.00	34.0000	365	10.0	70.0	25550	1.42E-08	5.00E+01	2.83E-10
CADMIUM (adult)	5.23E-06	0.60000	24.00	70.0000	365	30.0	70.0	25550	4.61E-07	6.10E+00	7.56E-08
CADMIUM (child)	5.23E-06	0.80000	24.00	34.0000	365	10.0	70.0	25550	7.59E-07	6.10E+00	1.24E-07
CHROMIUM (adult)	4.28E-06	0.60000	24.00	70.0000	365	30.0	70.0	25550	3.77E-07	4.10E+01	9.20E-09
CHROMIUM (child)	4.28E-06	0.80000	24.00	34.0000	365	10.0	70.0	25550	6.21E-07	4.10E+01	1.52E-08
NICKEL (adult)	4.71E-07	0.60000	24.00	70.0000	365	30.0	70.0	25550	4.15E-08	8.40E-01	4.94E-08
NICKEL (child)	4.71E-07	0.80000	24.00	34.0000	365	10.0	70.0	25550	6.84E-08	8.40E-01	8.14E-08

TOTAL CANCER RISK-ADULT	1.35E-07
TOTAL CANCER RISK-CHILD	2.22E-07

REFERENCES FOR ASSUMPTIONS: INHALATION (USEPA, 1989 (EFHJ), AIR CONCENTRATIONS FROM DISPERSION MODEL, SEE CALC. SHEETS.

Table 13

AR301476

AIRNC2

03-Apr-90

Site Name: HRANICA LANDFILL
Inhalation of Air Particulates in a Residential Setting
Noncarcinogenic Effects: Worst Case Scenario (ASH PIT AREA)
Receptor: Adult/Child

This table calculates estimated body doses and hazard indices.

The equations to calculate body dose level and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = CA * IR * ET * EF * ED / (BW * AT)$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	Standard/ Guideline (mg/kg/day)	Hazard Index
Toluene (Adult)	1.53E-10	0.60000	24.00	70.0000	365	30.0	30.0	10950	3.15E-11	2.00E+00	1.57E-11
Toluene (Child)	1.53E-10	0.80000	24.00	34.0000	365	10.0	10.0	6570	8.64E-11	2.00E+00	4.32E-11
Xylene (Adult)	2.75E-09	0.60000	24.00	70.0000	365	30.0	30.0	10950	5.66E-10	3.00E-01	1.89E-09
Xylene (Child)	2.75E-09	0.80000	24.00	34.0000	365	10.0	10.0	6570	1.55E-09	3.00E-01	5.18E-09
1,1,1-TCA (adult)	9.70E-11	0.60000	24.00	70.0000	365	30.0	30.0	10950	2.00E-11	3.00E-01	6.65E-11
1,1,1-TCA (child)	9.70E-11	0.80000	24.00	34.0000	365	10.0	10.0	6570	5.48E-11	3.00E-01	1.83E-10
BARIUM (adult)	4.83E-05	0.60000	24.00	70.0000	365	30.0	30.0	10950	9.94E-06	1.00E-04	9.94E-02
BARIUM (child)	4.83E-05	0.80000	24.00	34.0000	365	10.0	10.0	6570	2.73E-05	1.00E-04	2.73E-01
MANGANESE (adult)	8.28E-06	0.60000	24.00	70.0000	365	30.0	30.0	10950	1.70E-06	3.00E-04	5.68E-03
MANGANESE (child)	8.28E-06	0.80000	24.00	34.0000	365	10.0	10.0	6570	4.68E-06	3.00E-04	1.56E-02
SELENIUM (adult)	1.70E-06	0.60000	24.00	70.0000	365	30.0	30.0	10950	3.50E-07	1.00E-03	3.50E-04
SELENIUM (child)	1.70E-06	0.80000	24.00	34.0000	365	10.0	10.0	6570	9.60E-07	1.00E-03	9.60E-04

TOTAL HAZARD INDEX-ADULT	1.85E-01
TOTAL HAZARD INDEX-CHILD	2.89E-01

REFERENCES FOR ASSUMPTIONS: INHALATION RATE (USEPA, 1989 CEFHJ), AIR CONCENTRATIONS FROM DISPERSION MODEL, SEE CALC SHEETS

Table 14

AR301477

AIRCAON2 03-Apr-90

Site Name: HRANICA LANDFILL
Inhalation of Air Particulates: On-site tresspass scenario
Carcinogenic Effects: Most Probable Scenario (NON-ASH PIT AREA)
Receptor: ADULT/CHILD

This table calculates estimated body doses and incremental cancer risks.

The equations to calculate body dose level and incidental cancer rates are:

Body Dose = CA * IR * ET * EF * ED/ (BW * AT)
(mg/kg/day)

Cancer Rate = Body Dose (mg/kg/day) * Cancer Potency Factor (mg/kg/day)^-1

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	CPF (mg/kg/d)^-1	Incremental Carcinogenic Risk
PERCHLOROETHYLENE (adult)	3.14E-12	0.60000	8.00	70.0000	52	30.0	70.0	25550	1.31E-14	3.30E-03	4.34E-17
PERCHLOROETHYLENE (child)	3.14E-12	0.80000	8.00	34.0000	52	6.0	70.0	25550	7.22E-15	3.30E-03	2.38E-17
TRICHLOROETHYLENE (adult)	4.39E-12	0.60000	8.00	70.0000	52	30.0	70.0	25550	1.84E-14	1.72E-02	1.07E-12
TRICHLOROETHYLENE (child)	4.39E-12	0.80000	8.00	34.0000	52	6.0	70.0	25550	1.01E-14	1.72E-02	5.87E-13
ARSENIC (adult)	8.74E-09	0.60000	8.00	70.0000	52	30.0	70.0	25550	3.66E-11	5.00E+01	7.32E-13
ARSENIC (child)	8.74E-09	0.80000	8.00	34.0000	52	6.0	70.0	25550	2.01E-11	5.00E+01	4.02E-13
CADMIUM (adult)	2.40E-08	0.60000	8.00	70.0000	52	30.0	70.0	25550	1.00E-10	6.10E+00	1.65E-11
CADMIUM (child)	2.40E-08	0.80000	8.00	34.0000	52	6.0	70.0	25550	5.52E-11	6.10E+00	9.04E-12
CHROMIUM (adult)	7.48E-08	0.60000	8.00	70.0000	52	30.0	70.0	25550	3.13E-10	4.10E+01	7.64E-12
CHROMIUM (child)	7.48E-08	0.80000	8.00	34.0000	52	6.0	70.0	25550	1.72E-10	4.10E+01	4.19E-12
NICKEL (adult)	2.96E-08	0.60000	8.00	70.0000	52	30.0	70.0	25550	1.24E-10	8.40E-01	1.48E-10
NICKEL (child)	2.96E-08	0.80000	8.00	34.0000	52	6.0	70.0	25550	6.80E-11	8.40E-01	8.18E-11

TOTAL CANCER RISK-ADULT	1.73E-10
TOTAL CANCER RISK-CHILD	9.52E-11

REFERENCES FOR ASSUMPTIONS: INHALATION (USEPA, 1989 [EFH]), AIR CONCENTRATIONS FROM BOX MODEL, SEE CALC. SHEETS.

Table 15

AR301178

AIRNCON2

03-Apr-90

Site Name: HRANICA LANDFILL
Inhalation of Air Particulates: On-site tresspas scenario
Noncarcinogenic Effects: Most Probable Scenario (NON-ASH PIT AREA)
Receptor: Adult/Child

This table calculates estimated body doses and hazard indices.

The equations to calculate body dose level and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = CA * IR * ET * EF * ED / (BW * AT)$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
- CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
- IR = INHALATION RATE (m^3/hour)
- ET = EXPOSURE TIME (hours/day)
- EF = EXPOSURE FREQUENCY (days/year)
- BW = BODY WEIGHT (kg)
- AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	Standard/ Guideline (mg/kg/day)	Hazard Index
Toluene (Adult)	1.09E-11	0.68000	8.00	70.0000	52	30.0	30.0	10950	1.06E-13	2.00E+00	5.32E-14
Toluene (Child)	1.09E-11	0.80000	8.00	34.0000	52	6.0	6.0	2190	2.92E-13	2.00E+00	1.46E-13
Xylene (Adult)	2.64E-11	0.68000	8.00	70.0000	52	30.0	30.0	10950	2.58E-13	3.00E-01	8.60E-13
Xylene (Child)	2.64E-11	0.80000	8.00	34.0000	52	6.0	6.0	2190	7.00E-13	3.00E-01	2.36E-12
1,1,1-TCA (adult)	6.28E-12	0.68000	8.00	70.0000	52	30.0	30.0	10950	6.13E-14	3.00E-01	2.04E-13
1,1,1-TCA (child)	6.28E-12	0.80000	8.00	34.0000	52	6.0	6.0	2190	1.68E-13	3.00E-01	5.61E-13
BARIUM (adult)	2.32E-07	0.68000	8.00	70.0000	52	30.0	30.0	10950	2.27E-09	1.00E-04	2.27E-05
BARIUM (child)	2.32E-07	0.80000	8.00	34.0000	52	6.0	6.0	2190	6.22E-09	1.00E-04	6.22E-05
MANGANESE (adult)	9.53E-07	0.68000	8.00	70.0000	52	30.0	30.0	10950	9.31E-09	3.00E-04	3.10E-05
MANGANESE (child)	9.53E-07	0.80000	8.00	34.0000	52	6.0	6.0	2190	2.56E-08	3.00E-04	8.52E-05
SELENIUM (adult)	2.13E-09	0.68000	8.00	70.0000	52	30.0	30.0	10950	2.08E-11	1.00E-03	2.08E-08
SELENIUM (child)	2.13E-09	0.80000	8.00	34.0000	52	6.0	6.0	2190	5.71E-11	1.00E-03	5.71E-08
									TOTAL HAZARD INDEX-ADULT		5.37E-05
									TOTAL HAZARD INDEX-CHILD		1.47E-04

REFERENCES FOR ASSUMPTIONS: INHALATION RATE (USEPA, 1989 EEFH)), AIR CONCENTRATIONS FROM BOX MODEL, SEE CALC SHEETS

Table 16

AR301479

AIRCA_MP

03-Apr-98

Site Name: HRANICA LANDFILL
Inhalation of Air Particulates for a Residential Setting
Carcinogenic Effects: Most Probable Scenario (NON-ASH PIT AREA)
Receptor: ADULT/CHILD

This table calculates estimated body doses and incremental cancer risks.

The equations to calculate body dose level and incidental cancer rates are:

$$\text{Body Dose (mg/kg/day)} = CA \times IR \times ET \times EF \times ED / (BW \times AT)$$

$$\text{Cancer Rate} = \text{Body Dose (mg/kg/day)} \times \text{Cancer Potency Factor (mg/kg/day)}^{-1}$$

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	CPF (mg/kg/d)^-1	Incremental Carcinogenic Risk
PERCHLOROETHYLENE (adult)	3.98E-11	0.60000	24.00	70.0000	365	30.0	70.0	25550	3.51E-12	3.30E-03	1.16E-14
PERCHLOROETHYLENE (child)	3.98E-11	0.80000	24.00	34.0000	365	10.0	70.0	25550	5.78E-12	3.30E-03	1.91E-14
TRICHLOROETHYLENE (adult)	5.57E-11	0.60000	24.00	70.0000	365	30.0	70.0	25550	4.91E-12	1.72E-02	2.86E-10
TRICHLOROETHYLENE (child)	5.57E-11	0.80000	24.00	34.0000	365	10.0	70.0	25550	8.09E-12	1.72E-02	4.70E-10
ARSENIC (adult)	1.10E-07	0.60000	24.00	70.0000	365	30.0	70.0	25550	9.70E-09	5.00E+01	1.94E-10
ARSENIC (child)	1.10E-07	0.80000	24.00	34.0000	365	10.0	70.0	25550	1.60E-08	5.00E+01	3.19E-10
CADMIUM (adult)	3.04E-07	0.60000	24.00	70.0000	365	30.0	70.0	25550	2.68E-08	6.10E+00	4.39E-09
CADMIUM (child)	3.04E-07	0.80000	24.00	34.0000	365	10.0	70.0	25550	4.41E-08	6.10E+00	7.24E-09
CHROMIUM (adult)	9.48E-07	0.60000	24.00	70.0000	365	30.0	70.0	25550	8.36E-08	4.10E+01	2.04E-09
CHROMIUM (child)	9.48E-07	0.80000	24.00	34.0000	365	10.0	70.0	25550	1.38E-07	4.10E+01	3.36E-09
NICKEL (adult)	3.75E-07	0.60000	24.00	70.0000	365	30.0	70.0	25550	3.31E-08	8.40E-01	3.94E-08
NICKEL (child)	3.75E-07	0.80000	24.00	34.0000	365	10.0	70.0	25550	5.45E-08	8.40E-01	6.48E-08
									TOTAL CANCER RISK-ADULT		4.63E-08
									TOTAL CANCER RISK-CHILD		7.62E-08

REFERENCES FOR ASSUMPTIONS: INHALATION (USEPA, 1989 [EFH]), AIR CONCENTRATIONS FROM DISPERSION MODEL, SEE CALC. SHEETS.

Table 17

AR301480

AIRNC_MP
03-Apr-90

Site Name: HRANICA LANDFILL
Inhalation of Air Particulates in a Residential Setting
Noncarcinogenic Effects: Most Probable Scenario (NON-ASH PIT AREA)
Receptor: Adult/Child

This table calculates estimated body doses and hazard indices.

The equations to calculate body dose level and hazard indices are:

Body Dose (mg/kg/day) = CA * IR * ET * EF * ED/ (BW * AT)

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	Standard/ Guideline (mg/kg/day)	Hazard Index
Toluene (Adult)	1.38E-10	0.60000	24.00	70.0000	365	30.0	30.0	10950	2.84E-11	2.00E+00	1.42E-11
Toluene (Child)	1.38E-10	0.80000	24.00	34.0000	365	10.0	10.0	6570	7.79E-11	2.00E+00	3.90E-11
Xylene (Adult)	3.34E-10	0.60000	24.00	70.0000	365	30.0	30.0	10950	6.87E-11	3.00E-01	2.29E-10
Xylene (Child)	3.34E-10	0.80000	24.00	34.0000	365	10.0	10.0	6570	1.89E-10	3.00E-01	6.29E-10
1,1,1-TCA (adult)	7.95E-11	0.60000	24.00	70.0000	365	30.0	30.0	10950	1.64E-11	3.00E-01	5.45E-11
1,1,1-TCA (child)	7.95E-11	0.80000	24.00	34.0000	365	10.0	10.0	6570	4.49E-11	3.00E-01	1.50E-10
BARIUM (adult)	2.94E-06	0.60000	24.00	70.0000	365	30.0	30.0	10950	6.05E-07	1.00E-04	6.05E-03
BARIUM (child)	2.94E-06	0.80000	24.00	34.0000	365	10.0	10.0	6570	1.66E-06	1.00E-04	1.66E-02
MANGANESE (adult)	1.21E-05	0.60000	24.00	70.0000	365	30.0	30.0	10950	2.49E-06	3.00E-04	8.30E-03
MANGANESE (child)	1.21E-05	0.80000	24.00	34.0000	365	10.0	10.0	6570	6.83E-06	3.00E-04	2.28E-02
SELENIUM (adult)	2.70E-08	0.60000	24.00	70.0000	365	30.0	30.0	10950	5.55E-09	1.00E-03	5.55E-06
SELENIUM (child)	2.70E-08	0.80000	24.00	34.0000	365	10.0	10.0	6570	1.52E-08	1.00E-03	1.52E-05
									TOTAL HAZARD INDEX-ADULT		1.44E-02
									TOTAL HAZARD INDEX-CHILD		3.94E-02

REFERENCES FOR ASSUMPTIONS: INHALATION RATE (USEPA, 1989 (EFH)), AIR CONCENTRATIONS FROM DISPERSION MODEL, SEE CALC SHEETS

Table 18

AR301481

SGCAOS

383776

03-Apr-98

Site Name: HRANICA LANDFILL
Inhalation of Air Contaminants (SOIL GAS)
Carcinogenic Effects: On-Site Scenario
Receptor: ADULT/CHILD

This table calculates estimated body doses and incremental cancer risks.

The equations to calculate body dose level and incidental cancer rates are:

Body Dose = CA * IR * ET * EF * ED/ (BW * AT)
(mg/kg/day)

Cancer Rate = Body Dose (mg/kg/day) * Cancer Potency Factor (mg/kg/day)^-1

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	CPF (mg/kg/d)^-1	Incremental Carcinogenic Risk
BENZENE (adult)	4.42E-06	0.60000	8.00	70.0000	52	30.0	70.0	25550	1.85E-08	2.92E-02	5.40E-10
BENZENE (child)	4.42E-06	0.60000	8.00	34.0000	52	6.0	70.0	25550	1.02E-08	2.92E-02	2.97E-10
										SUMMARY CARCINOGENIC RISK	

REFERENCES FOR ASSUMPTIONS: INHALATION (USEPA, 1989 [EFH]), SOIL GAS CONCENTRATIONS FROM BOX MODEL, SEE CALC. SHEETS.

Table 19

AR301482

SGNCOS

383776

03-Apr-90

Site Name: HRANICA LANDFILL
Inhalation of Air Contaminants (SOIL GAS)
Noncarcinogenic Effects: On-Site Scenario
Receptor: Adult/Child

This table calculates estimated body doses and hazard indices.

The equations to calculate body dose level and hazard indices are:

Body Dose = CA * IR * ET * EF * ED/ (BW * AT)
(mg/kg/day)

Hazard Index = Body Dose (mg/kg/day) / Standard or Guideline (mg/kg/day)

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	Standard/ Guideline (mg/kg/day)	Hazard Index
Toluene (Adult)	2.82E-04	0.60000	8.00	70.0000	52	30.0	30.0	10950	2.75E-06	2.00E+00	1.38E-06
Toluene (Child)	2.82E-04	0.80000	8.00	34.0000	52	6.0	6.0	2190	7.56E-06	2.00E+00	3.78E-06
Xylene (Adult)	8.88E-03	0.60000	8.00	70.0000	52	30.0	30.0	10950	8.67E-05	3.00E-01	2.89E-04
Xylene (Child)	8.88E-03	0.80000	8.00	34.0000	52	6.0	6.0	2190	2.38E-04	3.00E-01	7.94E-04
									SUMMARY HI (Adult)		2.91E-04
									SUMMARY HI (Child)		7.98E-04

REFERENCES FOR ASSUMPTIONS: INHALATION RATE (USEPA, 1989 [EFH]), SOIL GAS CONCENTRATIONS FROM BOX MODEL, SEE CALC SHEETS

AR301483

Table 20

AIRCAEM 03-Apr-90

Site Name: HRANICA LANDFILL
Inhalation of Vapors in a Residential Setting
Carcinogenic Effects: Total Area
Receptor: ADULT/CHILD

This table calculates estimated body doses and incremental cancer risks.

The equations to calculate body dose level and incidental cancer rates are:

Body Dose (mg/kg/day) = CA * IR * ET * EF * ED/ (BW * AT)

Cancer Rate = Body Dose (mg/kg/day) * Cancer Potency Factor (mg/kg/day)^-1

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	CPF (mg/kg/d)^-1	Incremental Carcinogenic Risk
BENZENE (adult)	5.62E-05	0.60000	24.00	70.0000	365	30.0	70.0	25550	4.95E-06	2.92E-02	1.45E-07
BENZENE (Child)	5.62E-05	0.80000	24.00	34.0000	365	10.0	70.0	25550	8.16E-06	2.92E-02	2.38E-07

TOTAL CANCER RISK-ADULT	1.45E-07
TOTAL CANCER RISK-CHILD	2.38E-07

REFERENCES FOR ASSUMPTIONS: INHALATION (USEPA, 1989 [EFH]), SOIL GAS CONCENTRATIONS FROM BOX MODEL, SEE CALC. SHEETS.

AR301484

Table 21

AIRNCEM
03-Apr-90

Site Name: HRANICA LANDFILL
Inhalation of vapors in a Residential Setting
Noncarcinogenic Effects: Total Area
Receptor: Adult/Child

This table calculates estimated body doses and hazard indices.

The equations to calculate body dose level and hazard indices are:

$$\text{Body Dose (mg/kg/day)} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

$$\text{Hazard Index} = \frac{\text{Body Dose (mg/kg/day)}}{\text{Standard or Guideline (mg/kg/day)}}$$

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME (period over which exposure is averaged - days)

Constituent	Concentration (mg/m^3)	Inhalation Rate (m^3/hr)	Exposure Time (hours/day)	Body Weight (kg)	Exposure Frequency (days/year)	Exposure Duration (years)	Lifetime (years)	Averaging Time (days)	Body Dose (mg/kg/day)	Standard/ Guideline (mg/kg/day)	Hazard Index
Toluene (Adult)	3.57E-03	0.60000	24.00	70.0000	365	30.0	30.0	10950	7.34E-04	2.00E+00	3.67E-04
Toluene (Child)	3.57E-03	0.80000	24.00	34.0000	365	10.0	10.0	6570	2.02E-03	2.00E+00	6.72E-03
Xylene (Adult)	1.13E-01	0.60000	24.00	70.0000	365	30.0	30.0	10950	2.32E-02	3.00E-01	7.75E-02
Xylene (Child)	1.13E-01	0.80000	24.00	34.0000	365	10.0	10.0	6570	6.38E-02	3.00E-01	2.13E-01
								TOTAL HAZARD INDEX-ADULT			7.79E-02
								TOTAL HAZARD INDEX-CHILD			2.19E-01

REFERENCES FOR ASSUMPTIONS: INHALATION RATE (USEPA, 1989 [EFH]), SOIL CONCENTRATIONS FROM BOX MODEL, SEE CALC SHEETS

Table 22

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